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U.S. ENVIRONMENTAL PROTECTION AGENCY

Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
A	ampere(s)	
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps=2.22×10^{12} dpm
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	3.527×10^{-2} ounces= 2.205×10^{-3} pounds
Hz	hertz	cycle per second
kVp	kilovolt peak	
m	meter(s)	39.4 inches=3.28 feet
m^2	cubic meter(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
mi	mile(s)	
ml	milliliter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g
r/min	revolutions per minute	
s	second	
yr	year	

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RADIATION DATA AND REPORTS

Volume 15, Number 10, October 1974

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

CONTENTS

CONTENTS—continued

RADIATION DATA AND REPORTS

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U.S. ENVIRONMENTAL PROTECTION AGENCY

Russell E. Train, Administrator

Reports

Environmental Monitoring and Disposal of Radioactive Wastes From U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1973[1]

M. E. Miles, G. L. Sjoblom, and J. D. Eagles[2]

The environmental effect of disposal of radioactive wastes originating from U.S. Naval nuclear propulsion plants and their support facilities is assessed. The total radioactivity, less tritium discharged to all ports and harbors from the more than 100 Naval nuclear-powered ships and supporting tenders, Naval bases and shipyards was less than 0.002 curie in 1973. The total tritium released to all ports and harbors was less than 1 curie in 1973. This report confirms that procedures used by the Navy to control releases of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public.

The radioactivity in wastes discussed in this report originates in the pressurized water reactors of 103 U.S. Naval nuclear-powered submarines and 4 nuclear-powered surface ships in operation. Support facilities involved in construction, maintenance, overhaul and refueling of these nuclear propulsion plants include 9 shipyards, 11 tenders, and 2 submarine bases. This report describes disposal of radioactive liquid wastes, disposal of solid wastes and monitoring of the environment to determine the effect of radioactive releases. This report concludes that radioactivity associated with U.S. Naval nuclear-powered ships has had no significant or discernible effect on the quality of the environment. A summary of the radiological environmental information supporting this conclusion follows.

From the start of the Naval nuclear propulsion program, the policy of the U.S. Navy has been to reduce to the minimum practicable, the amounts of radioactivity released into harbors. Navy procedures to accomplish this have been reviewed with the U.S. Atomic Energy Commission (AEC) and the U.S. Environmental Protection Agency (EPA). The total radioactivity discharged within 12 miles from shore from all U.S. Naval nuclear-powered ships and their support facilities in recent years is shown in table 1.

Table 1. Total radioactivity discharged within 12 miles from shore from all U.S. Naval nuclear-powered ships and their support facilities, 1969–1973

Year	Number of ships in operation	Volume (1 000 gallons)	Radioactivity less tritium (curies)
1969	91	3 326	0.048
1970	96	2 571	.024
1971	100	1 089	<.002
1972	104	289	<.002
1973	107	<25	<.002

As a measure of the significance of these data, if one person were able to drink the entire amount of radioactivity discharged into any harbor in 1973, he would not exceed the annual radiation exposure permitted by the U.S. Atomic Energy Commission for its employees and licensees.

Although of less significance than the amount of radioactivity released, table 1 shows the volume of liquids released within 12 miles has been reduced from millions of gallons per year to less than 25 thousand gallons in 1973. This reduction was achieved by reduction of waste

[1] Previously released as Report NT–74–1 (April 1974).

[2] Nuclear Power Directorate, Naval Ship Systems Command, Department of the Navy.

generation and by processing and reuse of wastewater.

Environmental monitoring is conducted by the U.S. Navy in United States and foreign harbors frequented by U.S. naval nuclear-powered ships. This monitoring consists of analyzing harbor water and sediment samples for radioactivity associated with naval nuclear propulsion plants, radiation monitoring around the perimeter of support facilities and effluent monitoring. Environmental samples from each of these harbors are also checked at least annually by an AEC laboratory to ensure that analytical procedures are correct and standardized. The EPA has conducted independent surveys in United States harbors; results have been consistent with Navy results. These surveys have confirmed that U.S. naval nuclear-powered ships and support facilities have had no significant effect on the radioactivity of the marine environment.

Radioactive liquid waste disposal

Policy and procedures minimizing release of radioactivity in harbors

The policy of the U.S. Navy is to reduce to the minimum practicable the amounts of radioactivity released to the environment but particularly within 12 miles from shore including into harbors. This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated in EPA in 1970), U.S. Atomic Energy Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection, International Atomic Energy Agency, and National Academy of Sciences—National Research Council (*1–7*). Keeping releases small minimizes the radioactivity available to build up in the environment or to concentrate in marine life. To implement this policy of minimizing releases, the Navy has issued standard instructions defining the radioactive waste disposal limits and procedures to be used by U.S. Naval nuclear-powered ships and their support facilities. These instructions were reviewed and concurred in by the AEC and the U.S. Public Health Service. (The radiological surveillance organization of U.S. Public Health Service has since been moved to the U.S. Environmental Protection Agency.)

Source of radioactivity

In the shipboard reactors, pressurized water circulating through the reactor core picks up the heat of nuclear reaction. Reactor cooling water circulates through a closed piping system to heat exchangers which transfer the heat to water in a secondary steam system isolated from the primary cooling water. The steam is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Releases from the shipboard reactors occur primarily when reactor coolant water expands as a result of being heated to operating temperature; this coolant passes through a purification system ion exchange resin bed prior to being transferred from the ship.

The principal source of radioactivity in liquid wastes is from trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Radionuclides with half-lives greater than 1 day in these corrosion and wear products include tungsten-187, chromium-51, hafnium-181, iron-59, iron-55, zirconium-95, tantalum-182, manganese-54, cobalt-58, and cobalt-60. The predominant and also longest-lived of these is cobalt-60, which has a 5.3 year half-life; cobalt-60 also has the most restrictive concentration limit in water listed by organizations which set radiological standards (*1–3*) for these corrosion and wear radionuclides. Therefore, radioactive waste disposal is conservatively controlled by assuming that all the long-lived radioactivity is cobalt-60.

Support facilities are equipped with processing systems to remove most of the radioactivity from liquid waste prior to release into harbors. These liquid wastes result from transferring water from ships as well as decontaminating radioactivity contaminated piping systems and laundering anticontamination clothing worn by personnel.

Liquid waste releases in harbors

The total amounts of long-lived radioactiv-

Table 2. Radioactive liquid waste released to harbors from U.S. Naval nuclear-powered ships and their support facilities for 1969 through 1973 [a]

Facility	1969		1970		1971		1972		1973	
	Volume (1 000 gallons)	Radioactivity (curies)	Volume (1 000 gallons)	Radioactivity (curies)	Volume (1 000 gallons)	Radioactivity (curies)	Volume (1 000 gallons)	Radioactivity (curies)	Volume (1 000 gallons)	Radioactivity (curies)
Portsmouth, N.H.; Naval Shipyard	87	0.002	68	0.002	51	<0.001	25	<0.001	<1	<0.001
Groton-New London, Conn; Electric Boat Division, Tender at State Pier and Sub Base	615	.006	359	.004	258	<.001	151	<.001	<1	<.001
Newport News, Va; Newport News Shipbuilding	870	.022	1 466	.013	262	<.001	13	<.001	16	<.001
Norfolk, Va; Naval Shipyard and Tender	192	.005	98	.001	38	<.001	16	<.001	<1	<.001
Charleston, S.C.; Naval Shipyard and Tenders	191	.001	58	<.001	45	<.001	8	<.001	1	<.001
Pascagoula, Miss; Ingalls Nuclear Division	8	<.001	7	<.001	26	<.001	12	<.001	<1	<.001
San Diego, Calif; Tenders at Ballast Point	<1	<.001	<1	<.001	<1	<.001	<1	<.001	<1	<.001
Long Beach, Calif; Naval Shipyard and Base	2	<.001	121	.002	219	<.001	7	<.001	3	<.001
Vallejo, Calif; Mare Island Naval Shipyard	80	.001	136	<.001	98	<.001	16	<.001	<1	<.001
Bremerton, Wash; Puget Sound Naval Shipyard	152	.001	268	.002	90	<.001	38	<.001	2	<.001
Pearl Harbor, Hawaii; Naval Shipyard and Sub Base	1 279	.008	<1	<.001	<1	<.001	<1	<.001	<1	<.001
Apra Harbor, Guam	71	<.001	<1	<.001	<1	<.001	<1	<.001	<1	<.001
All other harbors, United States and foreign	<1	—	<1	—	<1	—	<1	—	<1	—
Total	3 326	0.048	2 571	0.024	1 089	<0.002	289	<0.002	<25	<0.002

[a] Radioactivity data has been standardized to cobalt-60 and excludes tritium. Volumes are prior to dilution. A total of 0.02 curie was discharged into the river at Quincy, Mass. from 1961 through March 1969 when all work on U.S. Naval nuclear-powered ships was discontinued at General Dynamics, Quincy Division. Slight differences in volumes and radioactivity data from past reports result from using more significant figures in this table. Volumes less than 500 gallons are shown as <1 thousand. Curies less than 0.0005 are shown as <0.001.

ity released into harbors and seas within 12 miles from shore during the past 5 years are summarized in table 2, which updates information in references *8* through *15*. Included are data on releases from U.S. nuclear-powered ships and from supporting shipyards, tenders and submarine bases. Locations listed in table 2 include all operating bases and home ports in the United States and overseas as well as all other ports which were visited by Naval nuclear-powered ships. The quantities of radioactivity listed in this table are conservatively reported as if the entire radioactivity consisted of cobalt-60, which is the predominant long-lived radionuclide and also has the most stringent concentration limits.

Although of less significance than the amount of radioactivity, the volume of waste has also been reduced. The average volume released into all harbors in the middle 1960's was 5 million gallons per year. In 1973, the volume released was less than 25 000 gallons. This reduction was achieved by reduction of waste generation and by processing and reuse of waste water.

The table shows that the total amount of radioactivity released within all United States and foreign harbors by the more than 100 nuclear-powered ships in the U.S. Navy has been less than 0.002 curie per year since 1970. To put this small quantity of radioactivity into perspective, it is less than the quantity of naturally occurring radioactivity (*16*) in the volume of saline harbor water occupied by a single nuclear-powered submarine.

Short-lived radionuclides

Reactor coolant also contains short-lived radionuclides with half-lives of seconds to hours. Their highest concentrations in reactor coolant are from nitrogen-16 (7 second half-life), nitrogen-13 (10 minute half-life), fluorine-18 (1.8 hour half-life), argon-41 (1.8 hour half-life), and manganese-56 (2.6 hour half-life). During 1973, the total quantity of these short-lived radionuclides was less than 0.001 curie in any release from any ship. For the longest-lived of these, about 1 day after discharge from an operating reactor, the concen-

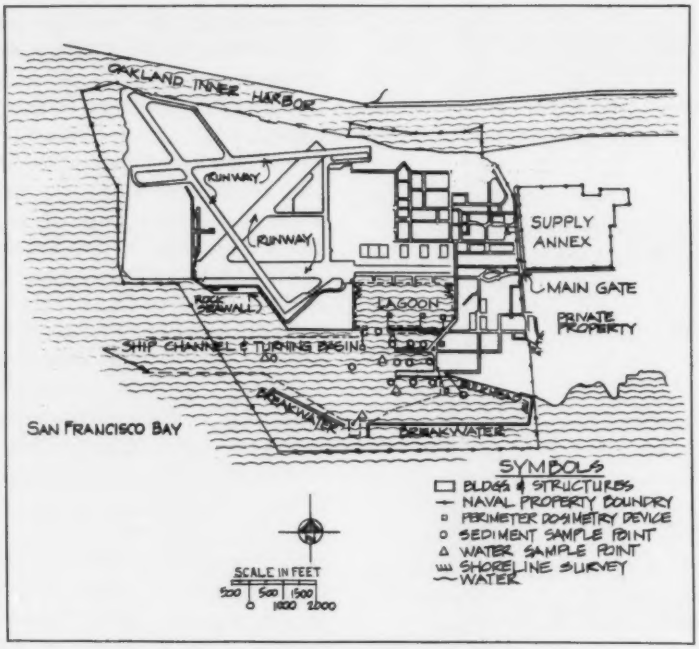

Figure 1. Environmental monitoring locations at the U.S. Naval Air Station, Alameda, Calif.

tration is reduced to one thousandth of the initial concentration and in about 2 days, the concentration is reduced to one millionth.

Most liquid releases from ships during new construction occur during heating up, prior to extensive power operation of the reactor and before any buildup of long-lived radionuclides in reactor coolant can occur. The total short-lived radioactivity of such releases in 1973 was less than 0.001 curie in 16 thousand gallons of water; these releases are included in table 2.

Fission product radionuclides

Fission products produced in the reactor are retained within the fuel elements. The fission gases, krypton and xenon, are also retained within the fuel elements. However, trace quantities of naturally occurring uranium impurities in reactor structural materials release small amounts of fission products to reactor coolant. The concentrations of fission products and the volumes of reactor coolant released are so low, however, that the total radioactivity attributed to long-lived fission product radionuclides, strontium-90 and cesium-137, in releases from U.S. Naval nuclear-powered ships and their support facilities has been less than 0.001 curie per year for all harbors combined. Fallout of these same fission products has often been more than this in one rainfall in a single harbor.

Tritium

Small amounts of tritium are formed in reactor coolant systems as a result of neutron interaction with the approximately 0.015 percent of naturally occurring deuterium present in water, and other nuclear reactions. Although tritium has a 12-year half-life, the radiation produced is of such low energy that its radioactivity concentration guide issued by the International Commission on Radiological Protection, the AEC and by other standard-setting organizations is 100 times higher than the concentration guide for cobalt-60. This tritium is in the oxide form and chemically indistinguish-

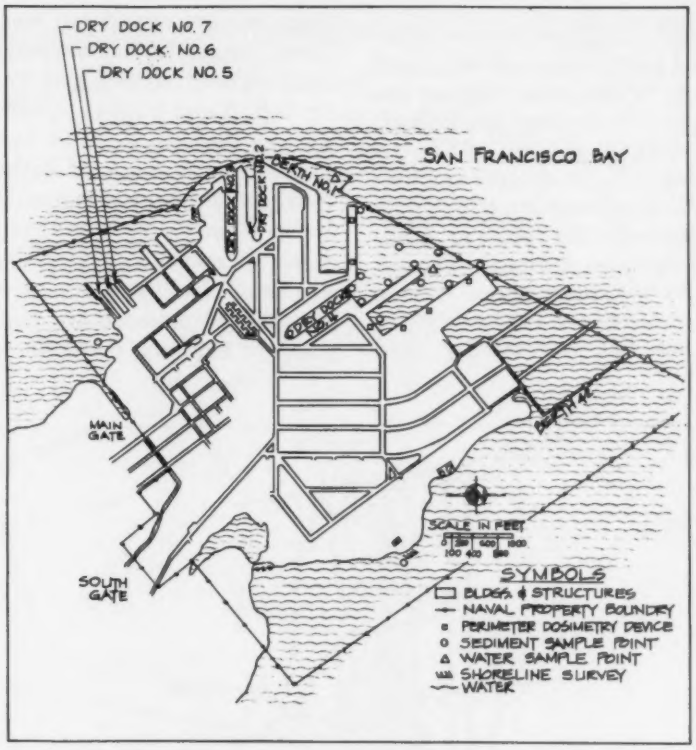

Figure 2. Environmental monitoring locations at the Hunters Point Naval Shipyard, San Francisco, Calif.

able from water; therefore it does not concentrate significantly in marine life or collect on sediment as do other radionuclides.

Tritium is naturally present in the environment because it is generated by cosmic radiation in the upper atmosphere. Reference *17* reports that the production rate from this source is about 6 million curies per year, which through rainfall causes a tritium inventory in the oceans of about 100 million curies. Because of this naturally occurring tritium, much larger releases of tritium than are conceivable from Naval nuclear reactors would be required to make a measurable change in the background tritium concentration.

The total amount of tritium released during each of the last 5 years from all U.S. Naval nuclear-powered ships and their supporting tenders, bases, and shipyards has been less than 200 curies. Most of this has been into the ocean more than 12 miles from shore. This total tritium from the entire nuclear Navy is less than typical electrical generating nuclear power stations release each year (*18,19*). Total tritium released into harbors within 12 miles was less than 1 curie in 1973. Such releases are too small to increase measurably the tritium concentration in the environment. Therefore, tritium has not been included in the data in other sections of this report.

Liquid waste releases at sea

Radioactive liquid wastes are released at sea under strict controls. These ocean releases are consistent with recommendations the Council on Environmental Quality made in 1970 to the President in reference *20*. Procedures and limits for ocean disposal have been consistent with recommendations made by the National Academy of Sciences—National Research Council in reference *5* and by the International Atomic Energy Agency in reference *6*. These releases have contained much less radioactivity than these reports considered would be acceptable. Total long-lived radioactivity excluding tritium, released farther than 12 miles from shore by U.S. Naval nuclear-powered ships and supporting tenders, is shown in table 3 for recent years. This is the total amount released from over 100 ships at different times of the year in the open sea at long distances from land in small incremental amounts, and under rapid dispersal conditions due to wave action. The quantity of radioactivity released to the open ocean in 1973 was 0.4 curie, which is less than

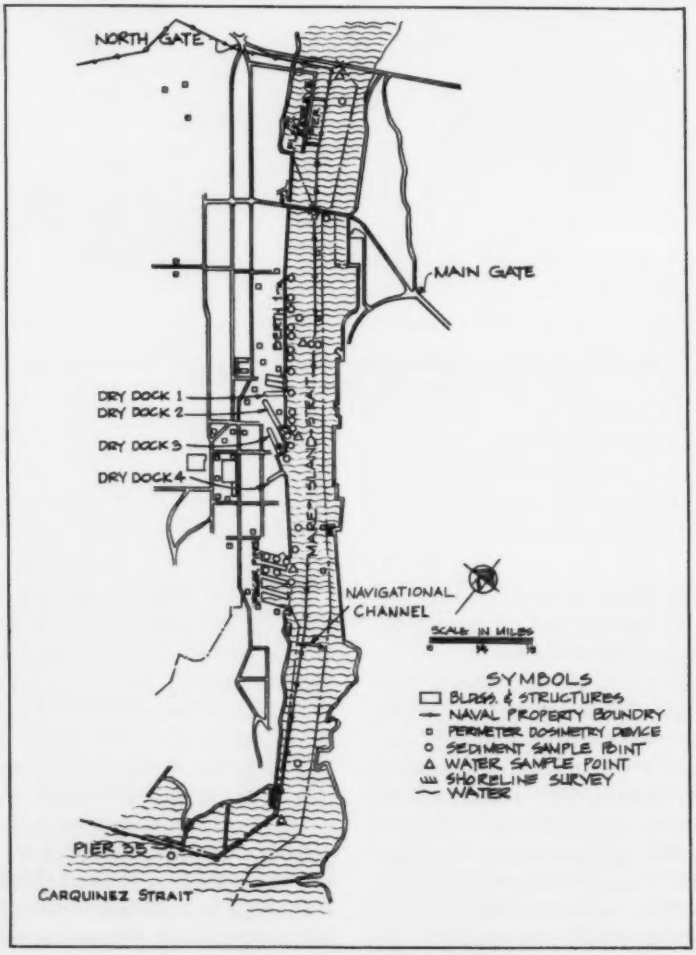

Figure 3. Environmental monitoring locations at the Mare Island Naval Shipyard, Vallejo, Calif.

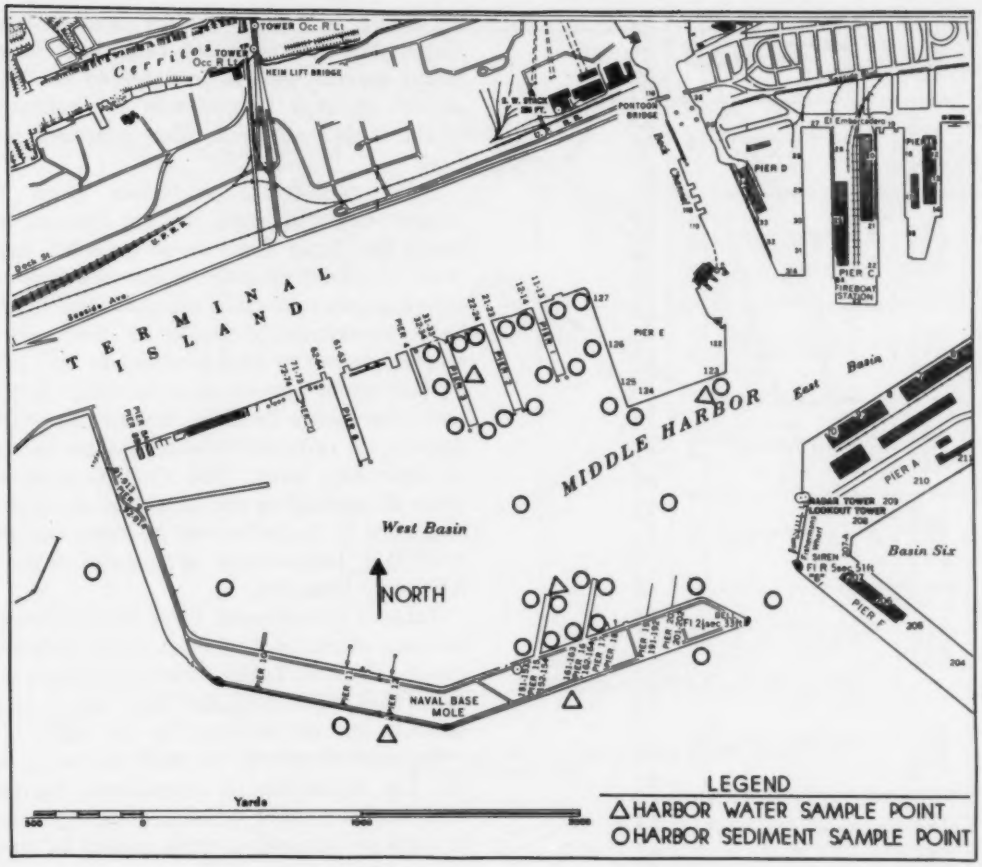

Figure 4. Environmental monitoring survey chart, Long Beach harbor, Calif.

Table 3. Total radioactive liquid waste released at sea by all U.S. Naval nuclear-powered ships and supporting tenders

Year	Volume (1 000 gallons)	Radioactivity less tritium (curies)
1969	1 570	1.7
1970	1 220	.8
1971	1 840	.8
1972	1 970	.6
1973	1 480	.4

the naturally occurring radioactivity in a cube of sea water approximately 100 yards on a side.

Solid radioactive waste disposal

During maintenance and overhaul operations, solid low-level radioactive wastes consisting of contaminated rags, plastic bags, paper, filters, ion exchange resin and scrap

Table 4. Radioactive solid waste from U.S. Naval nuclear-powered ships and their support facilities for 1969 through 1973 [a]

Facility	1969		1970		1971		1972		1973	
	Volume (1 000 cubic feet)	Radio-activity (curies)	Volume (1 000 cubic feet)	Radio-activity (curies)	Volume (1 000 cubic feet)	Radio-activity (curies)	Volume (1 000 cubic feet)	Radio-activity (curies)	Volume (1 000 cubic feet)	Radio-activity (curies)
Portsmouth, N.H.; Naval Shipyard	8	3	14	16	12	9	9	4	7	3
Groton, New London, Conn; Electric Boat Division, Tender at State Pier and Sub Base	8	328	12	140	18	13	7	6	12	2
Newport News, Va; Newport News Shipbuilding	17	382	28	312	21	165	10	8	6	5
Norfolk, Va; Naval Shipyard and Tender	6	8	9	146	10	33	10	1 026	4	2
Charleston, S.C.; Naval Shipyard and Tenders	15	9	8	6	6	4	7	34	6	19
Pascagoula, Miss; Ingalls Nuclear Division	1	<1	0	0	2	<1	2	2	1	4
San Diego, Calif; Tenders at Ballast Point	<1	2	<1	1	2	<1	<1	<1	<1	<1
Long Beach, Calif; Naval Shipyard and Base	<1	<1	<1	2	1	<1	<1	<1	<1	<1
Vallejo, Calif; Mare Island Shipyard	8	5	12	1 327	22	25	9	13	6	23
Bremerton, Wash; Puget Sound Naval Shipyard	11	42	18	4	21	59	9	22	10	21
Pearl Harbor, Hawaii; Naval Shipyard and Sub Base	4	3	5		4	2	4	147	7	143
Total	78	783	106	1 954	119	311	67	1 262	59	222

[a] This table includes all radioactive solid waste from tenders and nuclear-powered ships. This radioactivity is primarily cobalt-60. This radioactive waste is shipped to burial facilities licensed by the USAEC or State. Slight differences from past reports result from using different number of significant figures in this table. Volumes less than 500 cubic feet are reported as <1 thousand and less than 0.5 curie is reported as <1 curie.

materials are collected by nuclear-powered ships and their support facilities. Expended naval reactor fuel is transferred to the U.S. Atomic Energy Commission for reprocessing in the same manner as other expended nuclear fuel.

Solid radioactive materials from Naval nuclear-powered ships are not dumped at sea since the Navy procedures prohibit sea disposal of solid radioactive materials. Solid radioactive waste materials are packaged in strong tight containers, shielded as necessary and shipped to burial sites licensed by the AEC or a State under agreement with AEC. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. The Navy procedures require all packaging and shipping of radioactive materials to be performed in strict compliance with U.S. Department of Transportation and AEC requirements.

Table 4 summarizes total radioactivity and volumes of radioactive solid waste disposal for the last 5 years. Table 4 does not include wastes associated with expended fuel which is processed in special facilities by the AEC.

Because of efforts to minimize solid waste and the utilization of compaction equipment, total volumes have remained nearly constant in spite of increasing work caused by increasing number of ships. The average annual volume for the entire Naval nuclear propulsion program could be contained in a cube measuring 15 yards on a side. The radioactivity does not require excessively long time care in the licensed burial ground since the principal radionuclides do not have half-lives longer than 5 years. In 100 years, such radioactivity will have decayed to 1 millionth the initial radioactivity. In less than 200 years, the total of all radioactivity conservatively asumed to be cobalt-60 in table 4 will have decayed to less than 1 millionth of a curie and would not be detectable in the burial grounds using sensitive monitoring instruments.

Environmental monitoring

To provide additional assurance that procedures used by the U.S. Navy to control radioactivity are adequate to protect the en-

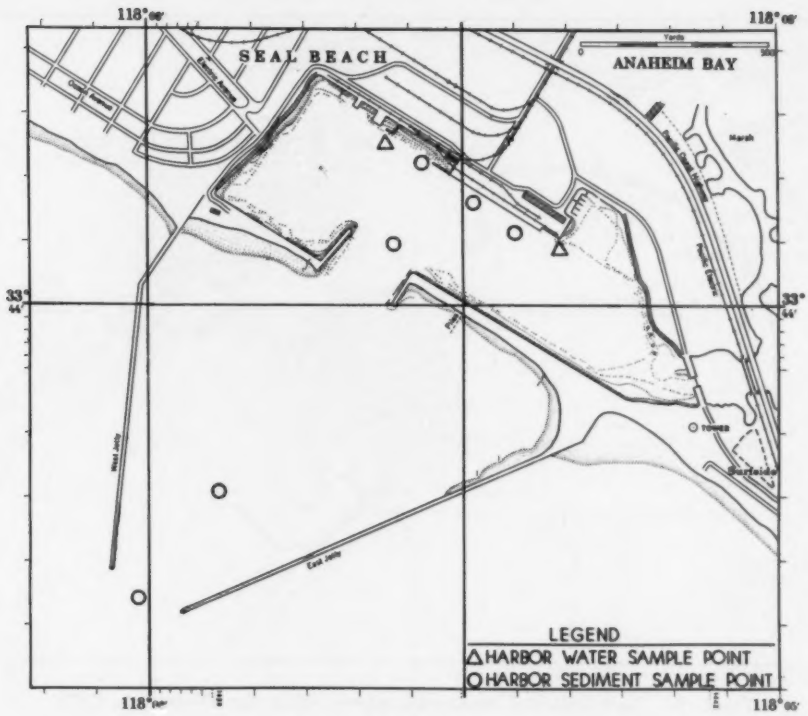

Figure 5. Environmental monitoring survey chart, Long Beach, California, Anaheim Bay area

vironment, the Navy conducts environmental monitoring in harbors frequented by its nuclear-powered ships. Environmental monitoring surveys for radioactivity are periodically performed in harbors where U.S. Naval nuclear-powered ships are built or overhauled and where these ships have home ports or operating bases. To ensure thoroughness and objectivity, these surveys are made as independent as practicable from waste disposal operations. Samples from each harbor monitored are also checked at least annually by an AEC laboratory to ensure analytical procedures are correct and standardized. These AEC laboratory results have been consistent with shipyard and operating base results. As a further independent check of environmental monitoring, a laboratory of the Environmental Protection Agency has conducted detailed surveys of selected harbors (*21–24*). This laboratory has monitored the harbors at Charleston, S.C.; Pearl Harbor, Hawaii; San Diego, Calif.; Vallejo, Calif.; New London, Conn.; Newport News, Va.; and Norfolk, Va. Navy monitoring results have been consistent with these surveys.

The current Navy environmental monitoring program consists of analyzing samples of harbor water and sediment, supplemented by shoreline surveys, posted dosimeters, and effluent monitoring.

Five water samples are taken in each harbor once each quarter year in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross gamma radioactivity and for cobalt-60 content. Samples are analyzed using

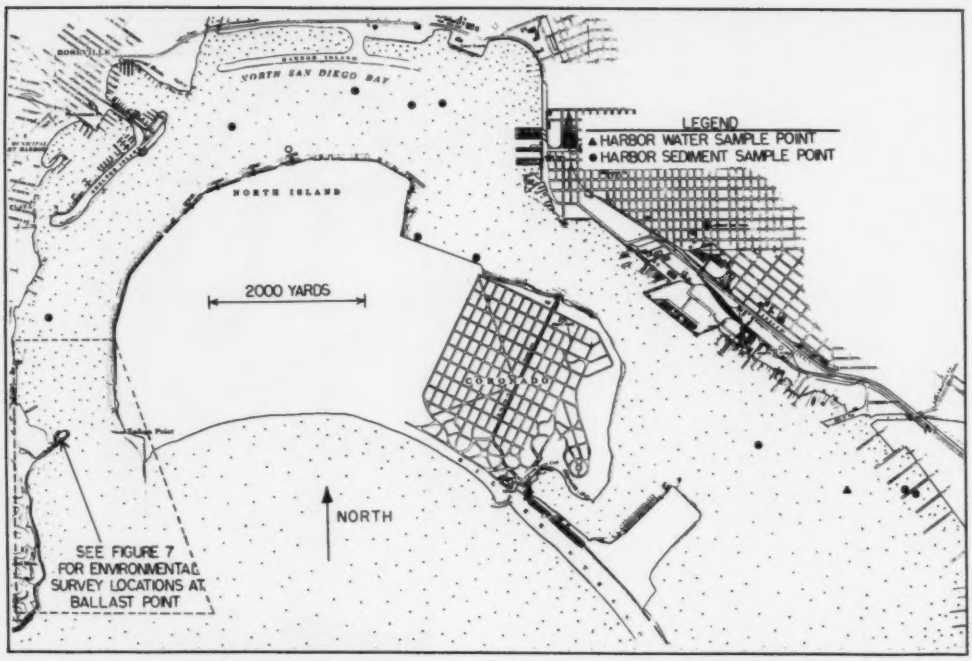

Figure 6. Environmental monitoring survey chart, San Diego Bay, Calif.

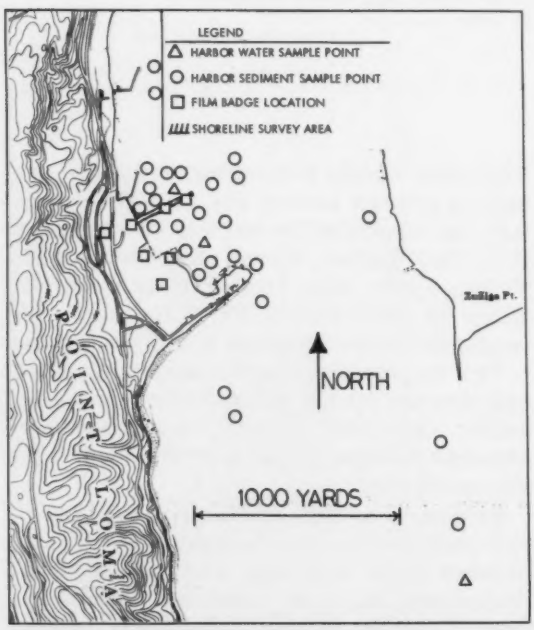

Figure 7. Environmental monitoring survey chart, Ballast Point, San Diego harbor, Calif.

a sodium iodide scintillation detector with a multichannel analyzer. Procedures for analysis will detect cobalt-60 if its concentration exceeds one three hundredth of the AEC limit (*1*). No cobalt-60 has been detected in any of the water samples from all harbors monitored.

A radiological laboratory now part of the Environmental Protection Agency analyzed samples from harbors to identify radionuclides present in sediment. These analyses showed cobalt-60 was the predominant radionuclide added to sediment from Naval nuclear reactor operations. Therefore, Navy monitoring procedures require collecting in each harbor approximately 20 to 120 sediment samples once each quarter year. Standard 6-inch square samplers modified to collect only the top ½ to 1 inch of sediment are used. The top layer was selected because it should be more mobile and more accessible to marine life than deeper layers. The samples are analyzed for gross gamma radioactivity and for cobalt-60. Results of the 2967 sediment samples from harbors

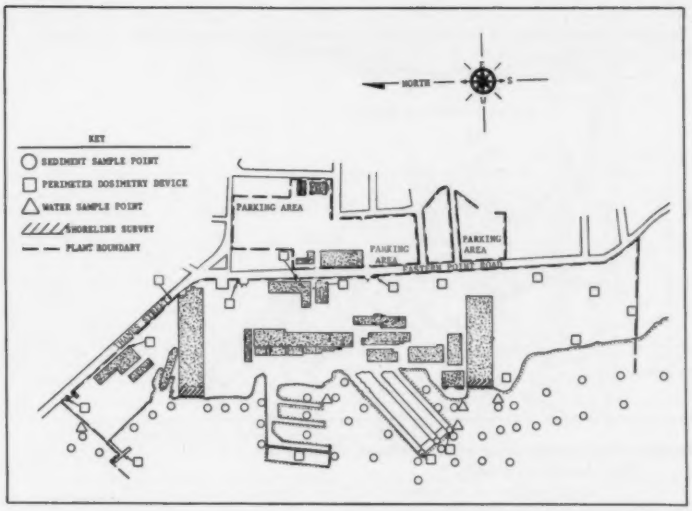

Figure 8. Environmental survey, General Dynamics/Electric Boat Groton, Conn.

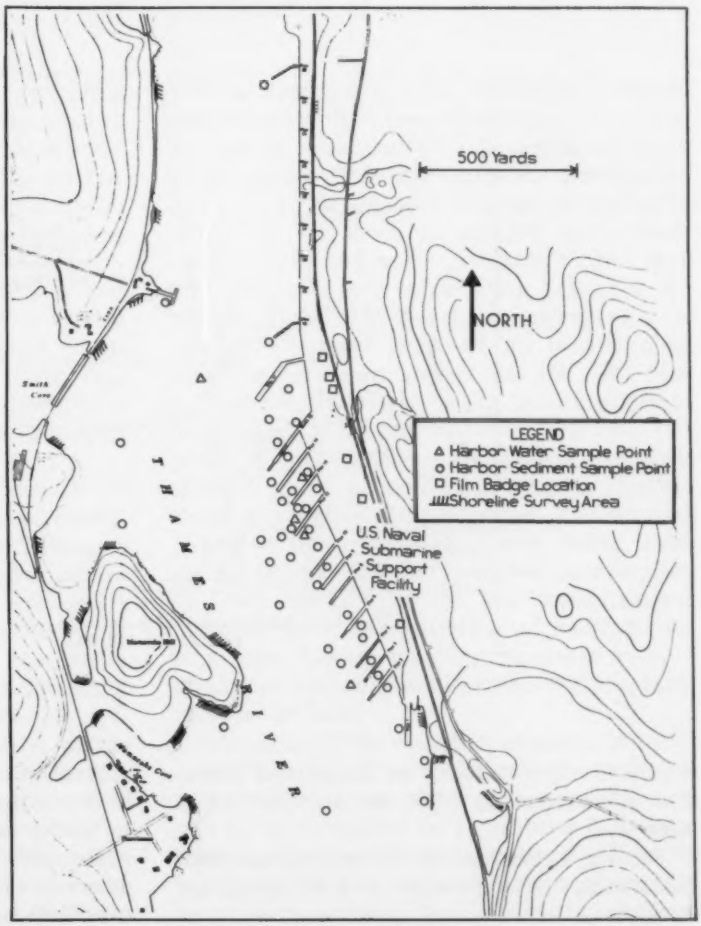

Figure 9. Environmental monitoring survey, U.S. Naval Submarine Support Facility, New London harbor, Conn.

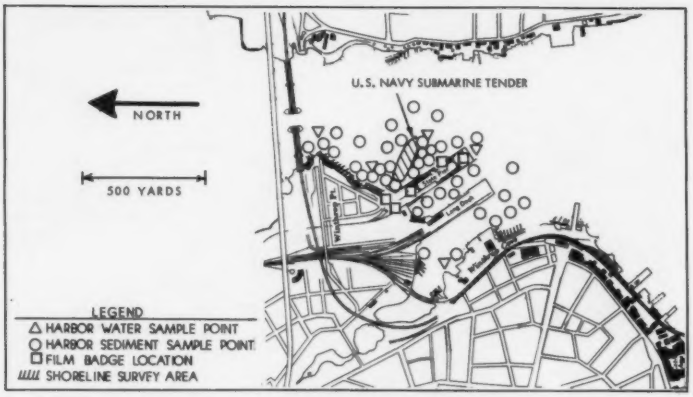

Figure 10. Environmental monitoring survey chart, State Pier, New London, Conn.

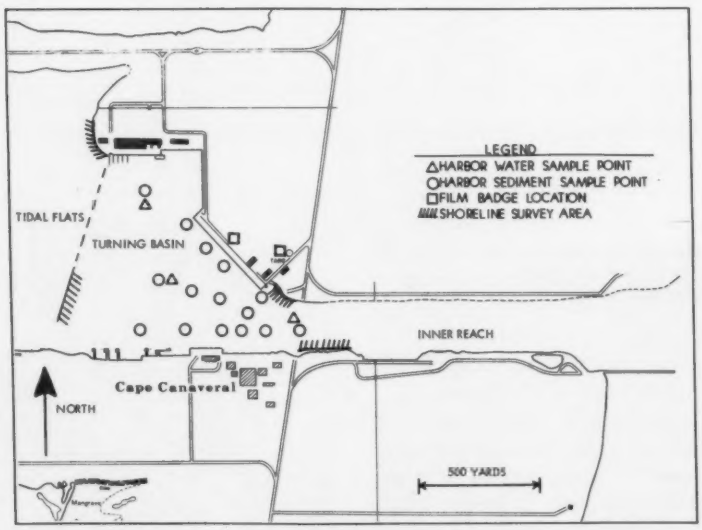

Fig. 11. Environmental monitoring survey chart, Port Canaveral, Fla.

monitored by the Navy in the United States and possessions for 1973 are summarized in table 5.

Figures 1 through 26 show environmental monitoring survey charts of U.S. ports and harbors.

Evaluation of the data summarized in table 5 shows that low-level cobalt-60 radioactivity in harbor bottom sediment is detected around a few piers at operating bases and shipyards where nuclear-powered ship maintenance and overhauls have been conducted over a period

Table 5. Summary of 1973 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled or built

Facility	Number of samples with cobalt-60			Total bottom area with cobalt-60 over 3 pCi/g[c] (km^2)	Estimated total cobalt-60 in top layer of sediment[d] (Ci)
	<3 (pCi/g)[a]	3–30 (pCi/g)[b]	>30–300 (pCi/g)		
Portsmouth, N.H.; Naval Shipyard	175	0	0	0	ND
Groton, New London, Conn; Electric Boat Division, State Pier and Submarine Base	384	22	0	0.1	0.02
Newport News, Va; Newport News Shipbuilding	152	0	0	0	ND
Norfolk, Va; Naval Shipyard and Base	344	0	0	0	ND
Charleston, S.C.; Naval Shipyard and Bases	416	0	0	0	ND
Pascagoula, Miss; Ingalls Nuclear Division	213	0	0	0	ND
San Diego, Calif; Navy Piers at Ballast Point	140	0	0	0	ND
Long Beach, Calif; Naval Shipyard and Base	160	0	0	0	ND
Vallejo, Calif; Mare Island Naval Shipyard	228	0	0	0	ND
Bremerton, Wash; Naval Shipyard and Base	212	0	0	0	ND
Pearl Harbor, Hawaii; Naval Shipyard and Sub Base	351	1	0	.001	ND
Apra Harbor, Guam	109	0	0	0	ND
Port Canaveral, Fla	60	0	0	0	ND

[a] Minimum detectable radioactivity is approxiately 1 pCi/g wet weight. Results in units of pCi/cm^2 range from 2 to 4 times the value of pCi/g.
[b] Maximum radioactivity in these samples was 19 pCi/g.
[c] One square kilometer is approximately equal to 0.4 square mile. Areas with cobalt-60 over 3 pCi/g were in immediate vicinity of piers used for berthing nuclear-powered ships.
[d] Where total cobalt-60 in the surface sediment layer is less than 0.01 curie, ND is reported. Samples more than 1 foot deep from several harbors show that total cobalt-60 present may be 2 to 5 times that measured in the surface layer.

of several years. Cobalt-60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U.S. harbor is less than 0.1 curie of cobalt-60. This radioactivity is small compared to background, since the quantity of naturally occurring radioactivity such as potassium-40, radium, uranium and thorium present in the sediment of a typical harbor amounts to hundreds of curies. Comparison to previous environmental monitoring data in references *8* through *15* shows that these environmental cobalt-60 levels have been steadily decreasing.

The first data column in table 5 includes all samples with less than 3 picocuries of cobalt-60 per gram of sediment. These low levels are difficult to measure because the levels of radioactivity in sediment from other sources are much higher. The value of 30 picocuries per gram was selected for the top of the second range of data since it corresponds to the upper limit for exposure in references *1* and *3*, even if consumed continuously by members of the general public. Although sediment cannot be consumed by humans, it might serve as a food source for marine life. Data on uptake of cobalt-60 by marine life obtained to date show that in the salt water harbor bottom environments, no significant buildup of cobalt-60 occurs in marine life. EPA evaluation in reference *23* shows that the cobalt-60 is in the form of metallic corrosion product particles which do not appear to be assimilated or transmitted in the food chain. The third range of up to 300 picocuries per gram is selected as a range which would not cause members of the general public to receive radiation exposure approaching the values set in references *1–4*. Concentrations of cobalt-60 up to 300 picocuries per gram are so low that the AEC does not require those who might possess them to be licensed. If concentrations higher than 300 picocuries per gram were to persist over substantial areas of a harbor bottom, further monitoring would be performed to determine if any of this radioactivity were being taken up by marine life for eventual consumption in food. Because of the low concentrations noted in table 5, monitoring of radioactivity in marine life has not been necessary as part of routine environmental monitoring programs in these harbors.

Estimates of the radiation exposure to members of the general public from radioactivity released into river and harbor waters and sediment and in air exhausted from facilities have been made as discussed in references *16* and *25* by analyzing the pathways whereby radioactivity might be transmitted from the marine environ-

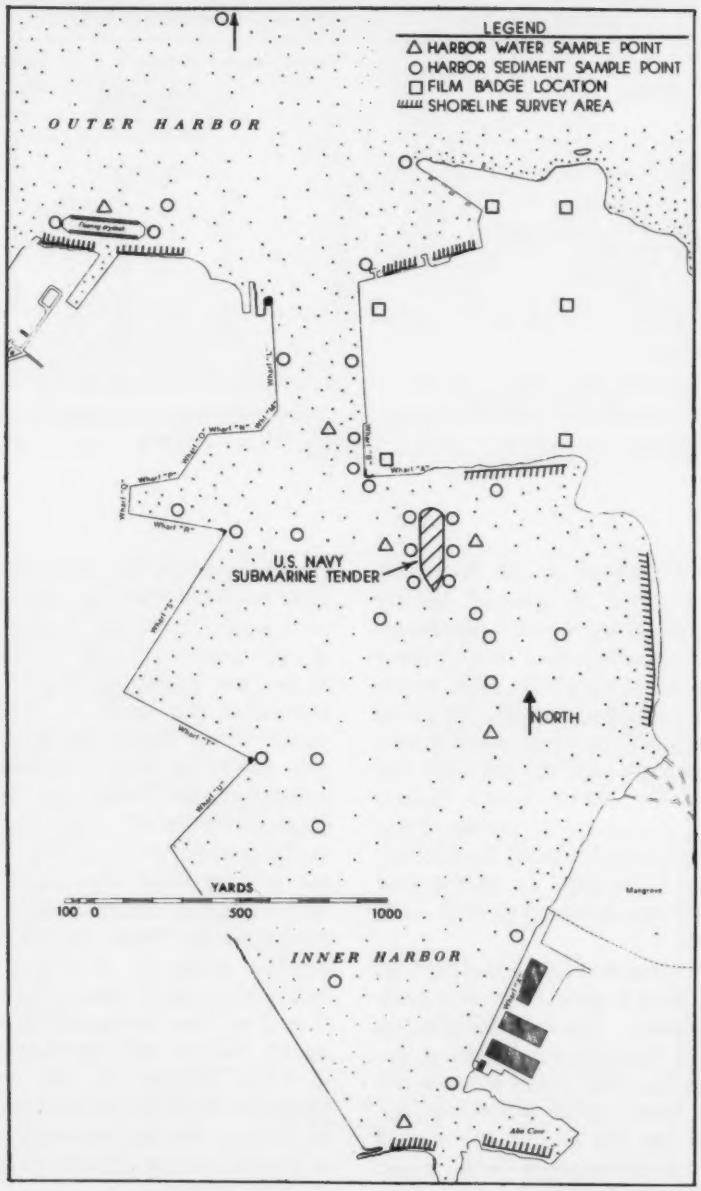

Figure 12. Environmental monitoring survey chart, Mariannas, Guam

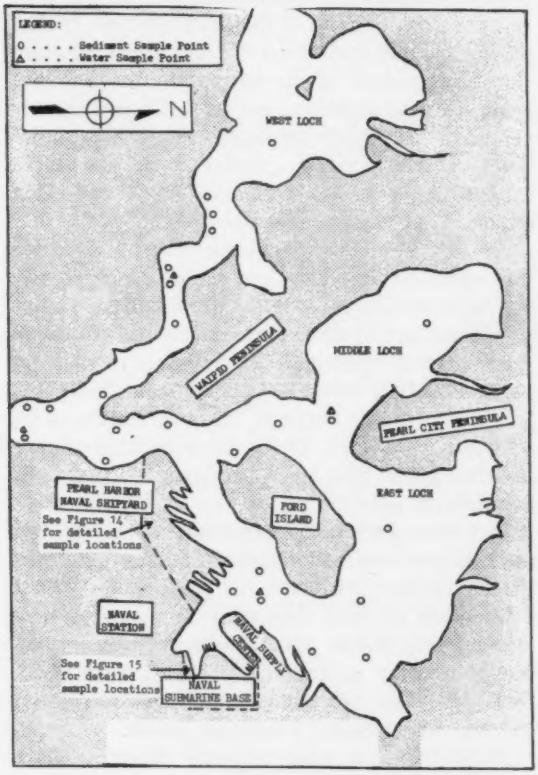

Figure 13. Overall map of Pearl Harbor, showing environmental monitoring locations in other areas of Pearl Harbor

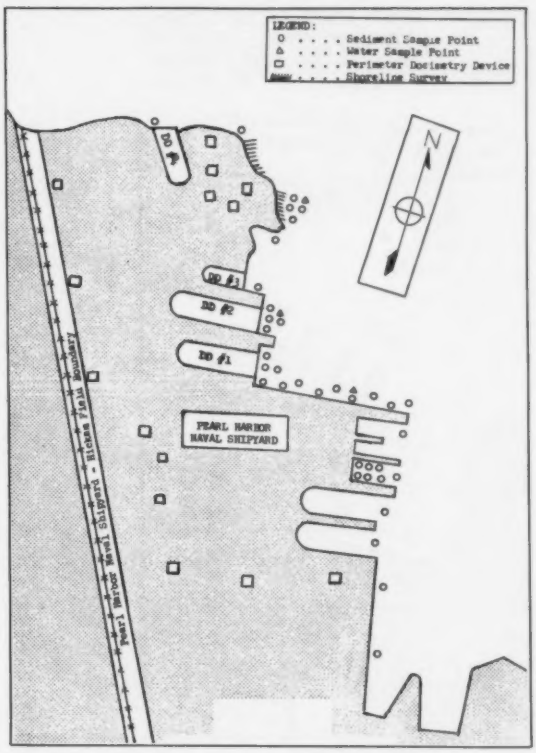

Figure 14. Environmental monitoring locations, Pearl Harbor Naval Shipyard

ment to man. These analyses considered direct exposure, such as to sediment along shorelines and by drinking harbor water, and indirect pathways such as consumption of bottom feeding fish or shellfish. These analyses showed that personal exposure from this radioactivity would be far too low to measure and could only be estimated. Based on radioactivity released, including the amounts and concentrations reported in table 2, the maximum radiation exposure in a year to any member of the general public would be less than 0.01 mrem. This is less than one ten-thousandth of the average annual exposure of 125 mrem (*7*) to members of the general public from natural radioactivity or from exposure to medical diagnostic x-rays. Reference *26* contains proposed guidelines for effluents from water-cooled nuclear power reactors including more restrictive exposure limits of 5 mrem per year for members of the public outside the facility. These new guidelines do not apply to nuclear-powered ships and support facilities; however, the dose from radioactivity releases from these facilities as estimated above is far less than the new guidelines.

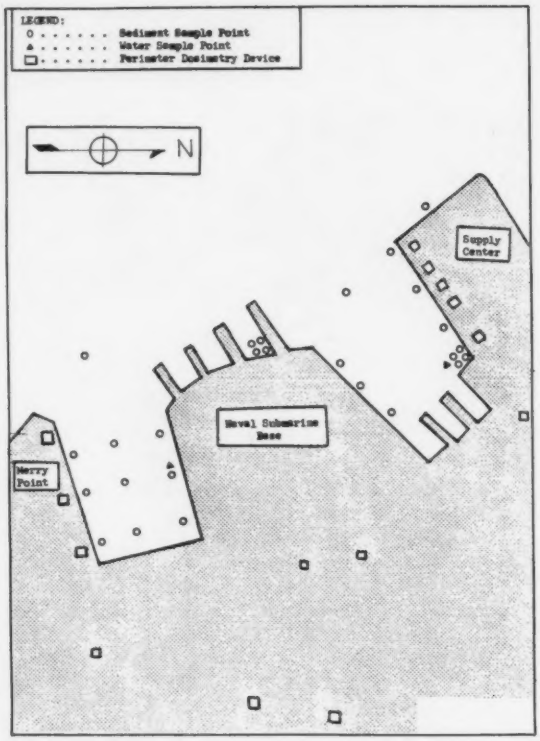

Figure 15. Environmental monitoring locations, Pearl Harbor Naval Submarine Base

For comparison, references *27* and *28* contain evaluations by AEC laboratories of the effects on the environment from the accumulation near points of discharge of radionuclides from several nuclear reactors. These reports conclude for these other reactors that radioactivity levels much greater than shown in table 5 have caused no significant radiation exposure to the general public.

In all monitored harbors, shoreline areas uncovered at low tide are surveyed twice per year for radiation levels with sensitive radiation detectors to determine if any radioactivity from bottom sediment washed ashore. All results were the same as background radiation levels in these regions, approximately 0.01 millirem per hour. Thus, there is no evidence in these ports that radioactivity from sediment is washing ashore.

Sensitive dosimeters are continuously posted at locations outside the boundaries of areas where radioactive work is performed. These dosimeters showed that radiation exposure to the general public from radioactive work on Naval nuclear propulsion plants within these facilities was not above that received from natural background radiation levels.

Naval nuclear reactors and their support facilities are designed to ensure there are no significant discharges of radioactivity in air-

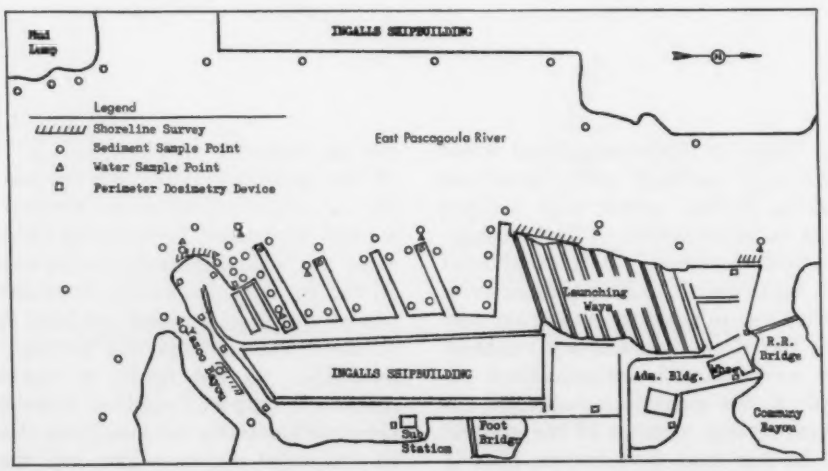

Figure 16. Ingalls Shipbuilding environmental monitoring survey

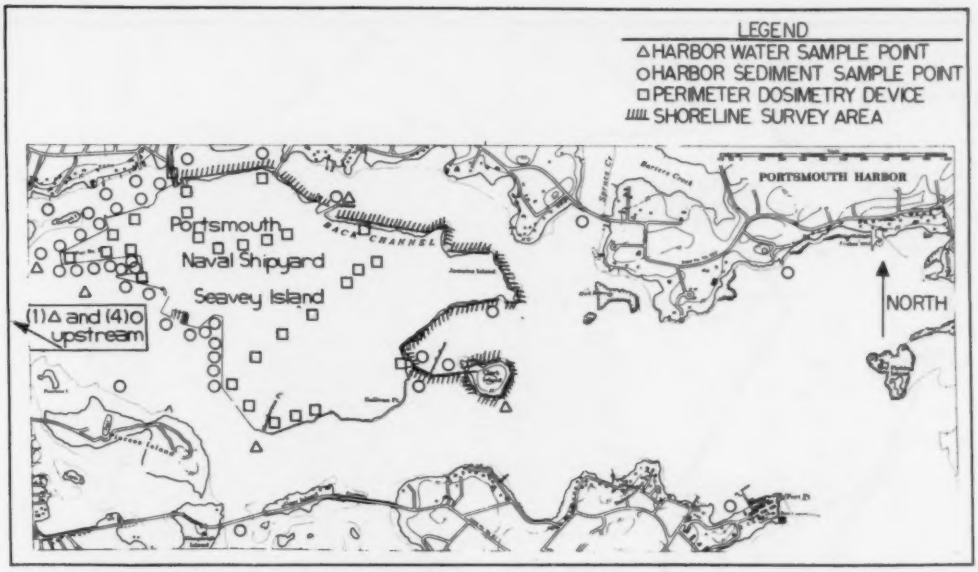

Figure 17. Environmental monitoring, Portsmouth Naval Shipyard, Portsmouth-Kittery harbor

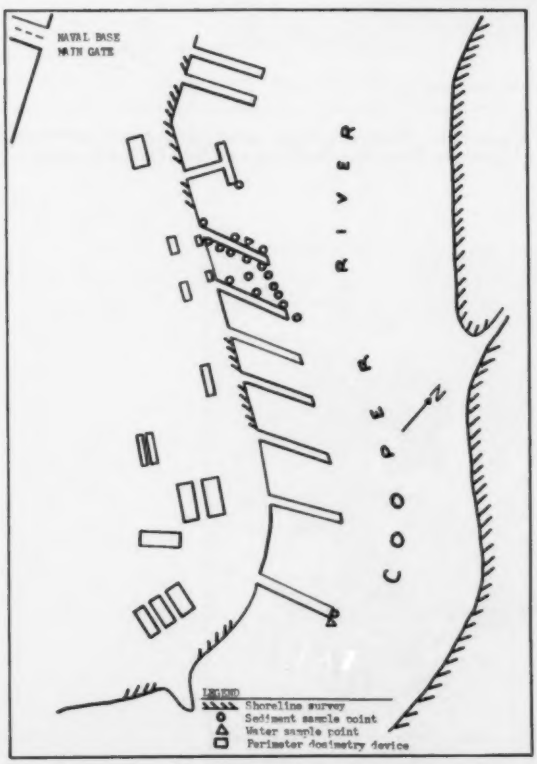

Figure 18. Environmental monitoring survey, Charleston Naval Station

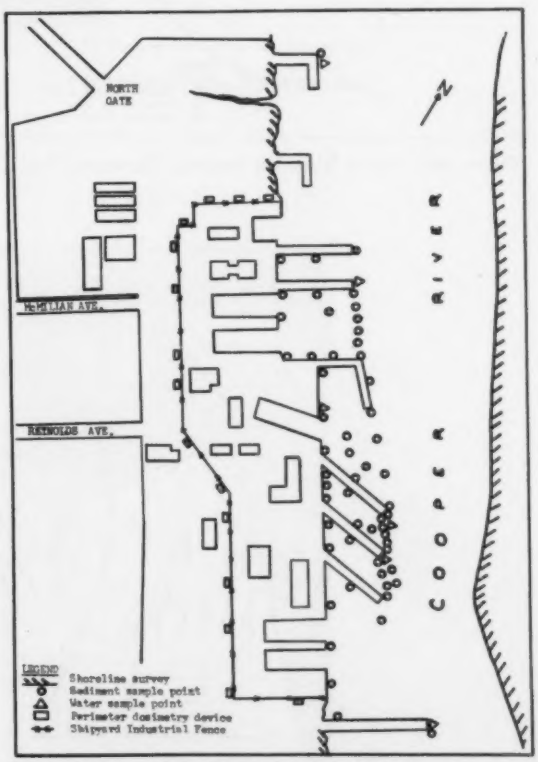

Figure 19. Charleston Naval Shipyard

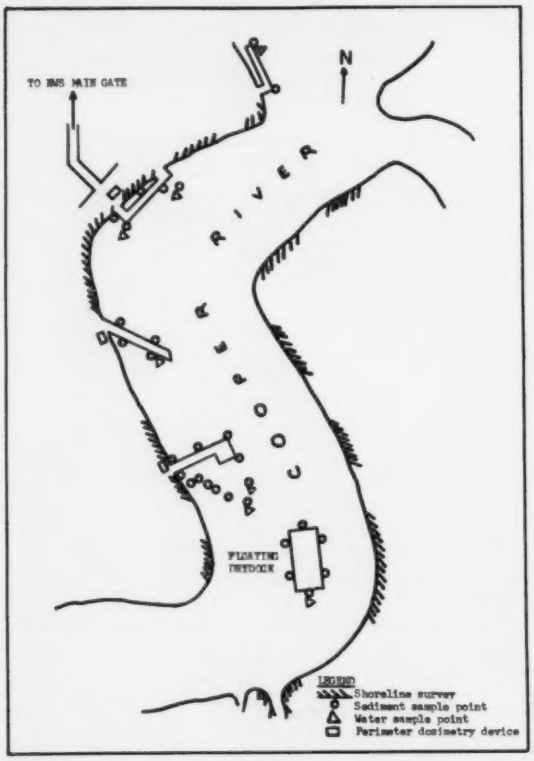

Figure 20. Naval Weapons Station, Charleston, S.C.

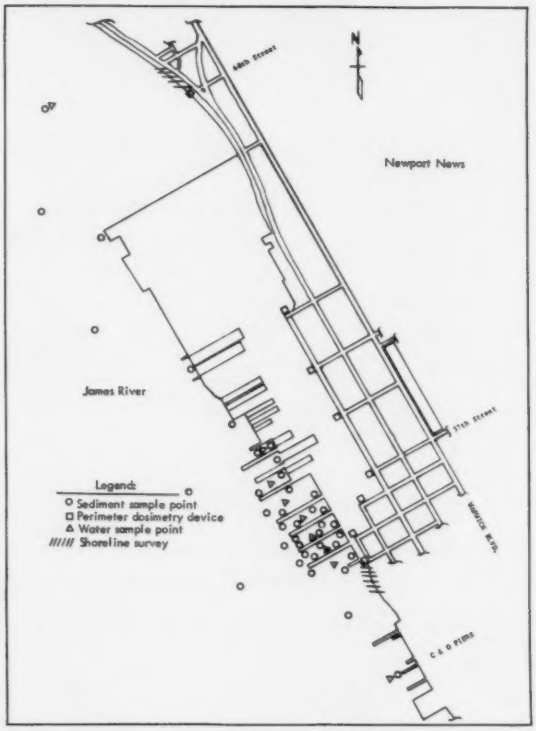

Figure 21. Environmental monitoring survey locations, Newport News Shipbuilding and Dry Dock Company

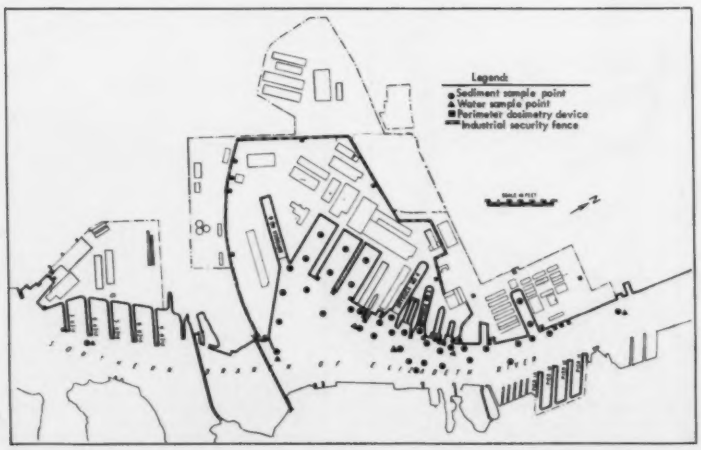

Figure 22. Environmental monitoring, Norfolk Naval Shipyard, Portsmouth, Va.

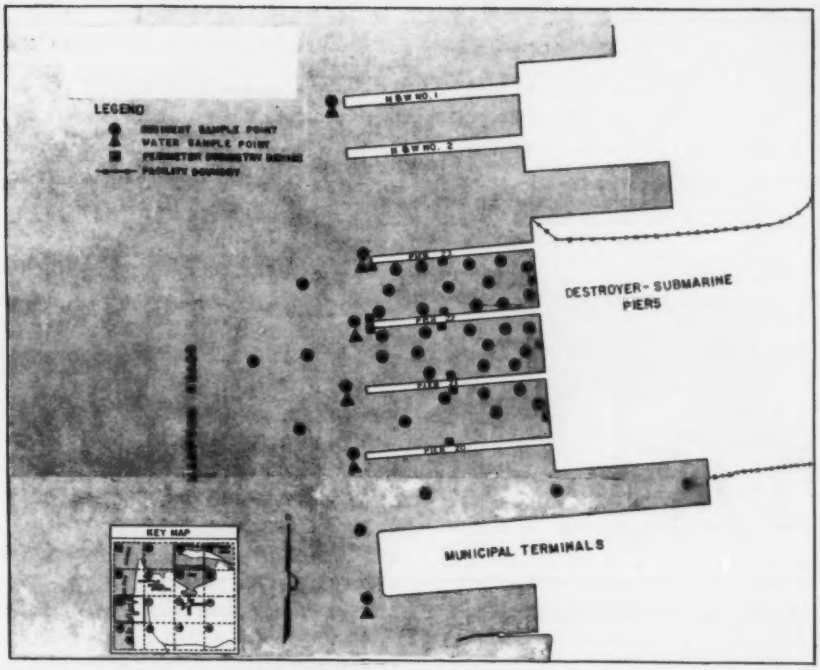

Figure 23. Norfolk Naval Station, destroyer, and submarine piers, Norfolk, Va.

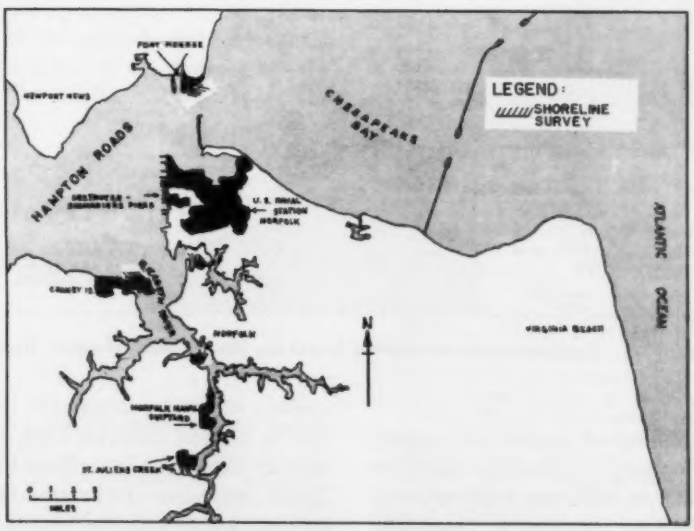

Figure 24. Shoreline radiation survey locations, Norfolk, Va.

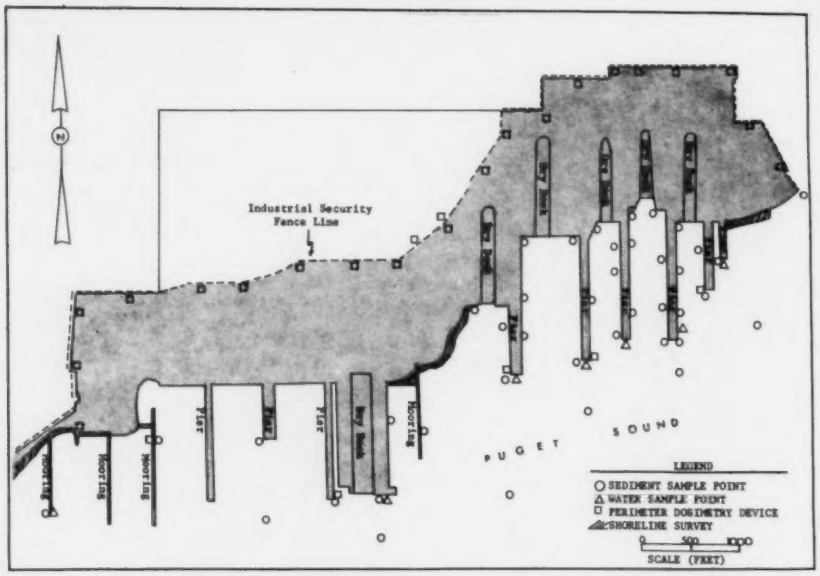

Figure 25. Environmental monitoring locations, Puget Sound Naval Shipyard, Bremerton, Wash.

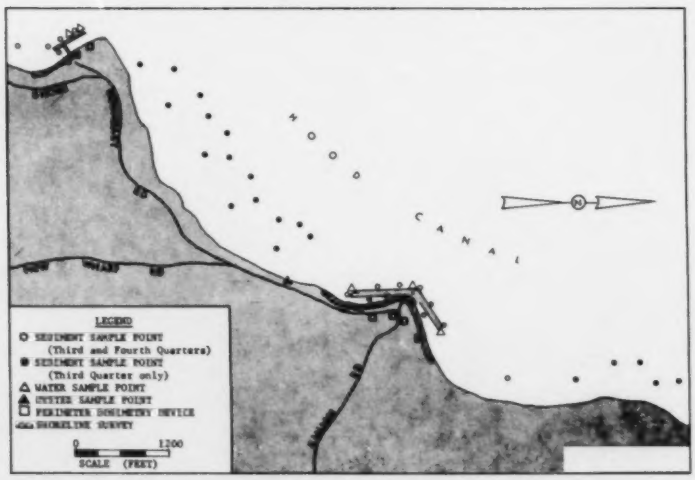

Figure 26. Environmental monitoring locations, Hood Canal, Bangor, Wash.

borne exhausts. Radiological controls are exercised in support facilities to preclude exposure of working personnel to airborne radioactivity exceeding limits such as specified in reference *1*. Further, all air exhausted from these facilities is passed through high efficiency particulate air filters and monitored during discharge. There were no discharges in airborne radioactivity above concentrations normally present in the atmosphere.

Conclusions

The total radioactivity, less tritium, released into all ports and harbors from the U.S. Naval nuclear propulsion program was less than 0.002 curie in 1973. The total tritium released into all ports and harbors was less than 1 curie in 1973.

No increase of radioactivity above normal background levels has been detected in harbor water where U.S. Naval nuclear-powered ships are based, overhauled, or constructed.

Liquid wastes from U.S. Naval nuclear-powered ships and support facilities have not caused a measurable increase in the general background radioactivity of the environment.

Low-level cobalt-60 radioactivity in harbor bottom sediment is detectable around a few piers at operating bases and shipyards where nuclear-powered ship maintenance and overhauls have been conducted over a period of several years. Cobalt-60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U.S. harbor of less than 0.1 curie of cobalt-60 is small compared to the naturally occurring radioactivity. Comparison to previous environmental data summarized in references *8* through *15* shows that these environmental cobalt-60 levels are continuing to decrease.

Procedures used by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities have been effective in protecting the environment and the health and safety of the general public.

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(*4*) Federal Radiation Council Memoranda, approved by President Eisenhower on May 13, 1960, President Kennedy on September 20, 1961, and President Johnson on July 31, 1964.

(*5*) NATIONAL ACADEMY OF SCIENCES — NATIONAL RESEARCH COUNCIL. Radioactive waste disposal from nuclear-powered ships, Publication 658. National Research Council, Washington, D.C. (1959).

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Radionuclides in Foods: Monitoring Program

R. E. Simpson, E. J. Baratta, and C. F. Jelinek[1]

In January 1973, the Food and Drug Administration notified its food monitoring program to include the radionuclides strontium-90, cesium-137, iodine-131, ruthenium-106, and potassium-40. Samples from eight composite food categories from each of eight separate total diet market baskets plus eight imported commodities from each of 13 separate cities were forwarded to the Winchester Engineering and Analytical Center for analysis. This paper describes the market basket program and gives a breakdown of the types of foods and quantities of each.

The radionuclide levels found in the total diets analyzed in Fiscal Year 1973 are within Range I of the appropriate guidelines, indicating the need for continued surveillance only at the present level.

The levels of radionuclides found in the limited types of edible imported commodities are low enough such that their contribution to the total diet would not be expected to raise the levels of these radionuclides above Range I of the guides.

In 1961, the Food and Drug Administration (FDA) initiated a program to monitor radioactivity, nutrients, and pesticides in the teenage total diet (*1,2*). This was expanded in 1964 to include the analysis for trace elements (*3*). In addition to the FDA, six other Federal, State and private organizations have conducted monitoring programs for radionuclides in foods in the past (*4*). A statistical study of data reported under these programs indicated all participating organizations were obtaining concordant results, which showed that the radioactivity levels in foods were below levels that would require protective action, and were declining as a result of the Test Ban Treaty. Because of this downward trend, and to prevent duplication of effort, FDA decided in 1969 to discontinue monitoring radionuclides in foods.

In accordance with the President's Reorganization Plan 3 of June 1970, the Institutional Diet Program (*5*) of the Bureau of Radiological Health was transferred to the Radiation Office of the Environmental Protection Agency (EPA). Since the low levels of radioactivity being observed approached the limits of analytical sensitivity, this program was cancelled by EPA in 1973.

With the projected growth of nuclear power and the resultant impact upon ecological systems, the monitoring for radioactivity within the environs and food-producing locations around reactor facilities becomes of increasing concern. There were, at the end of 1973, 96 nuclear plants either under construction or in operation in this country alone. It is anticipated that by the end of the century this number will be more than doubled (*6*). Therefore, in January 1973, the Office of the Commissioner, FDA, decided that a radiochemical analytical capability should be maintained by the FDA to perform and evaluate necessary analysis of foods in the event of a radiological incident and to note any upward trends in radioactive contamination of food that might develop (*7*).

[1] Robert E. Simpson, Bureau of Radiological Health, Food and Drug Administration, 5600 Fishers Lane, Rockville, Md. 20852. HFX-320: E. J. Baratta, chief, Analytical Quality Control System, Winchester Engineering and Analytical Center, 109 Holton St., Winchester, Mass. 01890; Charles F. Jelinek, Division of Chemical Technology, Bureau of Foods, Room 4013, FOB No. 8. Washington, D.C.

This program includes the analysis of strontium-90, cesium-137, iodine-131, ruthenium-106, and potassium-40, a naturally-occurring radionuclide.

Sample collections

For the purposes of the sampling program, "import" commodities are restricted to imported foods which have the domestic status indicated in table 1. "Total diet" is defined as representative food and drink consumed by a teenage male living in a moderate income family (*1*). The market basket shopping list, appendix A, is based upon the latest survey of the United States household consumption conducted by the U.S. Department of Agriculture (USDA) in 1965 (*8*).

Diet guides are provided for each of four geographic regions of the United States as defined by the USDA: Southeastern, Northeastern, Central, and Western. Each market basket represents the recommended 2-week diet of a 15–20 year old male for the region in which it is collected. It should be noted that appendix A reflects the diet for the Northeastern region. Diets for the other regions vary slightly from this.

Table 1. Commodities collected for import surveillance

Imported foods[a]	Remarks
1. Seafish, including shrimp	May be frozen or canned. The label should indicate foreign origin.
2. Cheese	The label should indicate foreign origin.
3. Fresh fruit, including bananas	Exclude pineapple from Hawaii.
4. Canned fruit, including pineapple	Same as 3 above.
5. Tea	A foreign origin label is preferred but "domestic" product may be substituted as necessary.
6. Coffee	Same as 5 above.
7. Cocoa powder	Same as 5 above.
8. Cashew nuts	Same as 5 above.

[a] A minimum of 2 pounds of each product.

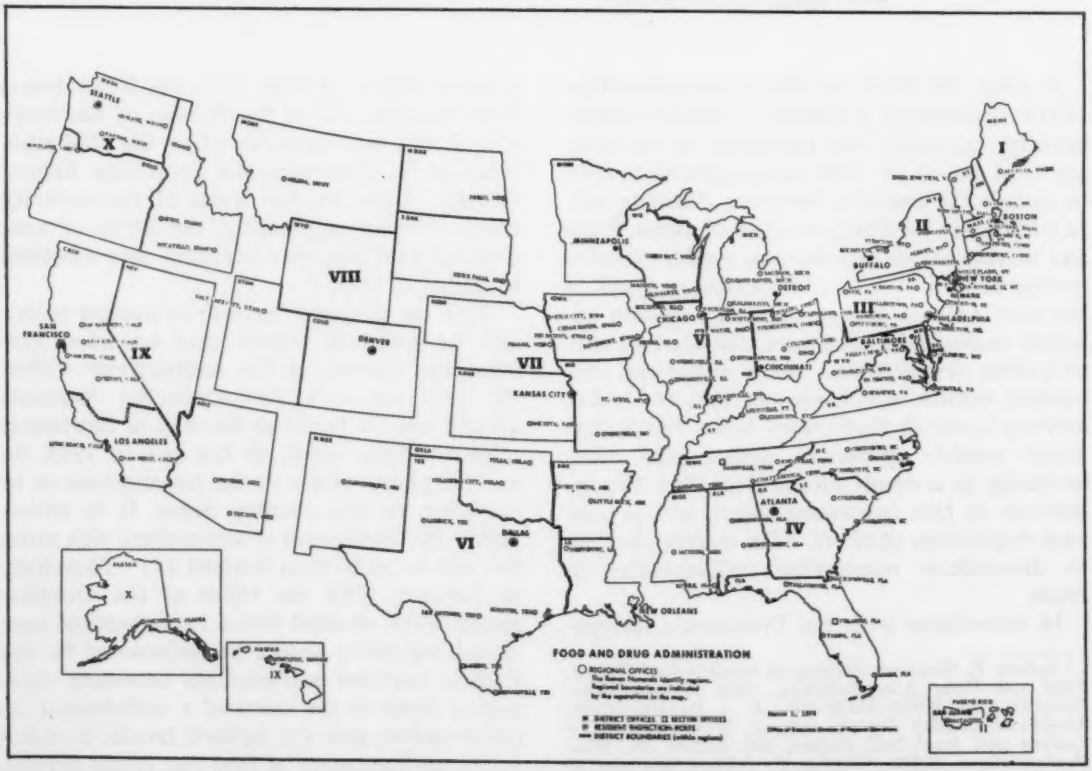

Figure 1. The Food and Drug Administration Regions and districts

The FDA inspectors from Boston, Buffalo, New York, Baltimore, Atlanta, New Orleans, Kansas City, Minneapolis, San Francisco, and Los Angeles collected samples within the Regions and Districts indicated in figure 1. The collection sites used in Fiscal Year 1973 are shown in tables 2 and 3. All import samples and market baskets collected by the designated FDA Districts were forwarded to the Kansas City Field Laboratory for processing and distribution (*3*). Each of the commodities of the market basket samples which are not normally eaten raw was prepared in a university dietary kitchen (under contract with the FDA) and then composited into the categories indicated in appendix A. The import commodities were handled separately. Portions of each of the eight total diet composites as well as the separate import products were forwarded from Kansas City to the Winchester Engineering Analytical Center (WEAC) for radionuclide analysis.

Procedures

Each of the samples is analyzed for strontium-90, cesium-137, iodine-131, ruthenium-106, and potassium-40. Cesium-137, iodine-131, ruthenium-106, and potassium-40 concentrations were determined by gamma-ray spectroscopy (*9*) and the gamma spectra were examined qualitatively for evidence of other gamma-emitting radionuclides. The strontium-90 is determined by beta-counting the daughter product, yttrium-90 (*10*). For purposes of quality control, selected samples are analyzed as blind duplicates.

All concentrations equal to or less than the minimum detectable limit of the appropriate radionuclide are reported as "not detectable" (ND). The minimum detectable limit is the concentration equal to the two-standard-deviation analytical error (*11*). For the radionuclides included in this report, the minimum detectable limits are: strontium-90, 0.5 pCi/kg; iodine-131, 10 pCi/kg; cesium-137, 10 pCi/kg; ruthenium-106, 10 pCi/kg; and potassium-40 expressed as 0.05 g stable potassium per kg of sample.

Discussion and results

In past monitoring programs, no consideration was given to the radioactivity levels in various imported food products. In order to determine whether there are any differences between radioactivity levels in such food products and domestic produce, the FDA included the eight import food items listed in table 1 in its monitoring program. Seafood is known to concentrate certain radionuclides (e.g., shellfish concentrate cesium-137 and cobalt-60) and therefore, should be early "indicators" of changes in radioactivity levels in marine foodstuffs of foreign origin. Cheese was selected as a possible indicator of levels of radioactivity in foreign milk products, while the fruits, nuts, tea, coffee and cocoa serve as examples of foreign produce where surface contamination may result from changes in environmental radioactivity.

Based upon an assumed average food consumption rate of 1.71 kg/day and the Radiation Protection Guides (RPG) recommended for Federal agencies by the Federal Radiation Council (FRC) (*12*), the following concentration ranges have been derived as guides applicable to foods (*13*):

	Range I (pCi/kg)	Range II (pCi/kg)	Range III (pCi/kg)
Cesium-137	0–360	360–3 600	3 600–360 000
Strontium-90	0– 20	20– 200	200– 2 000
Types of action recommended:	Periodic confirmatory surveillance	Quantitative surveillance-routine control	Evaluation and additional controls as necessary

Table 2a. Radionuclides in imported foods, canned fruit

Food type and treatment or condition	Country of origin [a]	Collection site	Collecting district (DO) or field (FO) office [b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K [c] (g K/kg)	^{90}Sr (pCi/kg)
Oranges, canned, syrup included:	Taiwan	Anaheim, Calif.	Los Angeles (LOS—DO)	1/ 2	ND	ND	ND	1.10±0.30	9.9 ±1.30
	Taiwan	Lake Charles, La.	New Orleans (NOL—DO)	1/ 8	ND	ND	ND	.81± .60	9.34±1.14
Fruit, mixed, jelled, canned	Japan	Bakersfield, Calif.	San Francisco (SAN—DO)	2/13	ND	ND	ND	ND	2.90± .70
Oranges, canned, syrup included	Taiwan	Atlanta, Ga.	Atlanta (ATL—FO)	2/26	ND	ND	ND	.94± .33	9.90±1.00
Pineapple, canned including syrup	Taiwan	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	ND	.99± .36	2.37± .64
Pineapple, canned including syrup	Taiwan	Lafayette, La	NOL—DO	3/12	ND	ND	ND	1.30± .30	2.26± .50
Papaya and syrup, canned	----------	Jersey City, N.J.	New York City (NYK—DO)	4/ 9	ND	ND	ND	.67± .27	3.38± .78
Oranges, mandarin, canned, syrup	Japan	Jericho, N.Y.	(NYK—DO)	4/30	ND	ND	ND	.92± .31	2.22± .58
Pineapple and syrup, canned	Mexico	Charleston, W. Va.	Baltimore (BAL—DO)	5/ 7	ND	ND	ND	1.74± .33	4.50± .80
Pineapple+oranges+syrup canned	Japan	New Britain, Conn.	Boston (BOS—FO)	6/11	ND	ND	ND	.99± .32	2.44± .56
Mandarin oranges, canned	Japan	Alliance, Nebr.	Kansas City, Kans. (KAN—DO)	6/20	ND	ND	ND	.79± .31	1.95± .66
Oranges and syrup, canned	Japan	Beloit, Wis.	Minneapolis MIN—DO	7/10	ND	ND	25±22	1.20± .30	4.20± .70
Average, $\bar{x}$	----------	----------	----------	----------	----------	----------	25	1.04	4.61
2 $S_{\bar{x}}$, among [d]	----------	----------	----------	----------	----------	----------		0.18	1.83
$2\sigma_{\bar{x}}$, counting error [e]	----------	----------	----------	----------	----------	----------	22	0.11	0.24
n	----------	----------	----------	----------	----------	----------	1	11	12

See footnotes at end of table.

Table 2b. Radionuclides in imported foods, fresh fruit

Food type and treatment or condition	Country of origin [a]	Collection site	Collecting district or field office [b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K [c] (g K/kg)	^{90}Sr (pCi/kg)
Bananas	Costa Rica	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	ND	3.38±0.4	ND
Bananas	----------	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	ND	4.43± .4	ND
Bananas	Costa Rica	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	ND	2.86± .37	1.8 ±0.7
Bananas	Costa Rica	Atlanta, Ga.	ATL—FO	2/26	ND	ND	ND	3.05± .37	.74± .6
Bananas	----------	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	ND	4.2 ± .5	.67± .50
Bananas	----------	Lafayette, La.	NOL—DO	3/12	ND	ND	ND	3.2 ± .4	.54± .50
Honeydew melon	Mexico	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	ND	2.74± .35	ND
Pears, fresh	Victoria, Australia	N. Massapequa, N.Y.	NYK—DO	4/24	ND	ND	ND	1.07± .34	1.26± .54
Bananas	Ecuador	Alliance, Nebr.	KAN—DO	6/20	ND	ND	ND	4.02± .42	ND
Bananas	Ecuador	New Britain, Conn.	BOS—FO	6/11	ND	ND	ND	3.50± .39	.54± .44
Bananas	Ecuador	Beloit, Wis.	MIN—DO	7/10	ND	ND	ND	3.7 ± .4	.58± .54
Average, $\bar{x}$	----------	----------	----------	----------	----------	----------	----------	3.29	0.87
2 $S_{\bar{x}}$, among [d]	----------	----------	----------	----------	----------	----------	----------	0.55	0.36
$2\sigma_{\bar{x}}$, counting error [e]	----------	----------	----------	----------	----------	----------	----------	0.12	0.2
n	----------	----------	----------	----------	----------	----------	----------	11	7

See footnotes at end of table.

These ranges conform to the FRC guides concerning transient rates of daily intake of radionuclides. The values are an adjunct to the guides applied in the EPA-FDA milk surveillance program (*14*) and are based upon an RPG dose of 0.17 rad/year to suitable samples of the population for the bone marrow dose from strontium-90 and 0.17 rad/year whole-body dose due to cesium-137.

For purposes of the evaluation it was conservatively assumed that each of the commodities of imported samples or total diet composites would be consumed at the rate of 1.71 kg/day for comparison with the above range limitations.

The results of the imported food survey presented in tables 2a through 2h show no iodine-131 or ruthenium-106 present within detectable limits in any of the individual food samples, and no detectable cesium-137 in fruit, both

Table 2c. Radionuclides in imported foods, fish

Food type and treatment or condition	County of origin[a]	Collection site	Collecting district or field office[b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (g K/kg)	^{90}Sr (pCi/kg)
Shrimp	Mexico	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	32 ±24	1.67 ±0.90	ND
Shrimp	Taiwan	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	ND	1.42 ± .50	0.9 ±0.64
Kipp, herring (canned)	Scotland	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	38 ±24	4.82 ± .42	2.4 ± .90
	Scotland	Atlanta, Ga.	ATL—FO	2/26	ND	ND	81 ±24	3.79 ± .40	3.4 ±1.0
Mackerel, canned	Japan	Lafayette, La.	NOL—DO	3/12	ND	ND	ND	3.20 ± .40	.80 ± .64
Kipp, herring (canned)	Scotland	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	35 ±22	4.00 ± .40	1.81 ± .82
Fish, canned	Israel	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	ND	1.50 ± .34	5.4 ± .86
Kipp, herring	Scotland	N. Massapequa, N.Y.	NYK—DO	4/24	ND	ND	232 ±17	3.40 ± .40	2.7 ± .90
Tuna, canned	Japan	New Britain, Conn.	BOS—FO	6/11	ND	ND	ND	2.53 ± .38	ND
Herring fillet	W. Germany	Alliance, Nebr.	KAN—DO	6/20	ND	ND	49 ±29	1.68 ± .44	ND
Mackerel, canned	Japan	Beloit, Wisc.	MIN—DO	7/10	ND	ND	26 ±22	3.40 ± .40	2.30 ± .80
Average, $\bar{x}$							70.4	2.9	2.45
2 $S_{\bar{x}}$, among[d]							55.6	0.7	1.04
$2\sigma_{\bar{x}}$, counting error[e]							8.8	0.14	0.29
n							7	11	8

See footnotes at end of table.

Table 2d. Radionuclides in imported foods, cheese

Food type and treatment or condition	Country of origin[a]	Collection site	Collecting district or field office[b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (g K/kg)	^{90}Sr (pCi/kg)
Cheese, feta	Denmark	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	ND	0.68 ±0.30	19.80 ±1.60
Cheese, semisoft	France	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	ND	ND	43.60 ±2.20
Cheese	France	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	ND	.80 ± .30	50.00 ±2.40
Cheese	Denmark	Atlanta, Ga.	ATL—FO	2/26	ND	ND	ND	.87 ± .29	5.20 ±1.00
Cheese	Denmark	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	ND	.40 ± .30	41.70 ±2.60
Cheese	Denmark	Lafayette, La.	NOL—DO	3/12	ND	ND	ND	.40 ± .30	35.80 ±2.00
Cheese, soft	Denmark	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	ND	.50 ± .32	44.00 ±3.00
Cheese, semisoft	Denmark	N. Massapequa, N.Y.	NYK—DO	4/24	ND	ND	ND	.42 ± .30	28.70 ±2.00
Cheese	Switzerland	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	141 ±22	.66 ± .30	101.70 ±4.40
Swiss cheese	Finland	New Britain, Conn.	BOS—FO	6/11	ND	ND	ND	.93 ± .33	80.30 ±4.10
Gruyere cheese	Switzerland	Alliance, Nebr.	KAN—DO	6/20	ND	ND	ND	.81 ± .33	83.10 ±3.70
Cheese	Denmark	Beloit, Wis.	MIN—DO	7/10	ND	ND	ND	.5 ± .3	38.8 ±2.1
Average, $\bar{x}$							141	0.63	47.7
2$S_{\bar{x}}$, among[d]								0.12	16.0
$2\sigma_{\bar{x}}$, counting error[e]							22	0.09	0.8
n							1	11	12

See footnotes at end of table.

fresh and canned. The strontium-90 levels in fruit were either below detectable limits or well within Range I of the above guides. Similar results were also indicated for all samples of imported fish.

In 10 of the 12 samples of imported cheese, the levels of strontium-90 were observed to be within Range II. With the exception of one apparent anomaly, cesium-137 was below detectable limits in all samples of cheese.

In the case of both coffee and tea, analyses were performed on both unbrewed and brewed samples. It is interesting to note that—particularly in the case of tea—the normal brewing operation was effective in significantly lowering both the cesium-137 and strontium-90 levels in the samples as brewed for normal consumption. The usual form of consumption of these commodities is in the brewed state. As such, following the previously mentioned conserv-

Table 2e, Radionuclides in imported foods, coffee

Food type and treatment or condition	Country of origin[a]	Collection site	Collecting district or field office[b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (g K/kg)	^{90}Sr (pCi/kg)
Coffee		Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	105 ±53	19.1 ±1.10	NA
Coffee, brewed				1/ 2	NA	NA	NA	NA	15.6 ±3.22
Coffee		Lake Charles, La.	NOL—DO	1/ 8	ND	ND	54 ±43	21.20 ±1.40	NA
Coffee, brewed				1/ 8	NA	NA	NA	NA	9.18 ±1.25
Coffee		Bakersfield, Calif.	SAN—DO	2/13	ND	ND	189 ±49	20.28 ±1.07	NA
Coffee, brewed				2/13	NA	NA	NA	NA	30.90 ±2.20
Coffee		Atlanta, Ga.	ATL—FO	2/26	ND	ND	ND	18.87 ±1.05	NA
Coffee, brewed				2/26	NA	NA	NA	NA	20.50 ±1.70
Coffee		Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	80 ±50	19.90 ±1.10	NA
Coffee, brewed				3/ 5	ND	ND	34 ±25	17.12 ±0.66	13.20 ±1.60
Coffee		Lafayette, La.	NOL—DO	3/12	ND	ND	ND	19.50 ±1.0	NA
Coffee, brewed				3/12	ND	ND	32 ±25	15.80 ±0.50	12.80 ±1.40
Coffee		Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	ND	21.00 ±1.10	26.40 ±2.80
Coffee, brewed				4/ 9	ND	ND	42 ±24	14.60 ±0.60	8.40 ±1.30
Coffee	Colombia	N. Massaequa, N.Y.	NYK—DO	4/24	ND	ND	ND	18.60 ±1.10	37.80 ±3.20
Coffee, brewed				4/24	ND	ND	ND	15.90 ±0.70	15.40 ±1.50
Coffee		Charleston, W. Va:	BAL—DO	5/ 7	ND	238 ±204	ND	18.10 ±1.00	24.30 ±4.00
Coffee, brewed				5/ 7	ND	ND	ND	15.20 ±0.60	10.50 ±1.30
Coffee		New Britain, Conn.	BOS—FO	6/11	ND	ND	ND	19.60 ±1.10	13.30 ±2.30
Coffee, brewed				6/11	ND	ND	ND	15.60 ±1.90	10.70 ±2.40
Coffee		Alliance, Nebr.	KAN—DO	6/20	ND	ND	75 ±49	18.40 ±1.10	27.00 ±2.90
Coffee, brewed				6/20	ND	ND	54 ±26	16.50 ±0.70	11.60 ±1.40
Coffee	Colombia	Beloit, Wisc.	MIN—DO	7/10	ND	ND	94 ±50	17.50 ±1.00	16.70 ±2.30
Average, $\bar{x}$:									
Coffee							99.5	19.3	24.3
Coffee, brewed[f]							40.5	15.8	14.4
$2\,S_{\bar{x}}$, among:									
Coffee							38.5	0.65	7.0
Coffee, brewed							9.98	0.62	3.9
$2\sigma_{\bar{x}}$, counting error:									
Coffee							20.0	0.32	1.2
Coffee, brewed							12.5	0.34	0.56
n Coffee							6	12	6
Coffee, brewed							4	7	11

See footnotes at end of table.

Table 2f. Radionuclides in imported foods, tea

Food type and treatment or condition	Collection site	Collecting district or field office[b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (g K/kg)	^{90}Sr (pCi/kg)
Tea	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	385 ±57	22.90 ±1.20	NA
Tea, brewed[e]				ND	ND	NA	NA	22.50 ± 2.52
Tea	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	320 ±56	22.64 ±0.50	NA
Tea, brewed			1/ 8	NA	NA	NA	NA	58.2 ± 5.25
Tea, loose	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	161 ±63	19.86 ±1.26	NA
Tea, brewed			2/13	NA	NA	NA	NA	45.00 ± 5.20
Tea, loose	Atlanta, Ga.	ATL—FO	2/26	ND	ND	436 ±62	20.05 ±1.26	NA
Tea, brewed			2/26	NA	NA	NA	NA	44.6 ± 4.90
Tea, (from bags)	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	167 ±51	21.5 ±1.11	NA
Tea, brewed			3/ 5	ND	ND	135 ±62	16.60 ±1.20	25.80 ± 3.00
Tea, loose	Lafayette, La.	NOL—DO	3/12	ND	ND	366 ±55	19.80 ±1.20	NA
Tea, brewed			3/12	ND	ND	247 ±65	16.90 ±1.30	45.1 ± 3.90
Tea, (from bags)	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	325 ±54	20.50 ±1.20	593 ±18
Tea, brewed			4/ 9	ND	ND	203 ±63	15.70 ±1.20	86.80 ± 5.40
Tea, loose	Plainview, N.Y.	NYK—DO	4/25	ND	ND	276 ±57	19.50 ±1.10	472 ±15
Tea, brewed			4/25	ND	ND	250 ±67	15.70 ±1.00	26.5 ± 3.40
Tea	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	268 ±49	18.70 ±1.10	331.10 ±11.00
Tea, brewed			5/ 7	ND	ND	137 ±69	15.00 ±1.30	38.20 ± 3.70
Tea, in bags	New Britain, Conn.	BOS—FO	6/11	ND	ND	330 ±62	20.56 ±1.20	289 ±12
Tea, brewed			6/11	ND	ND	236 ±78	16.60 ±1.40	14.2 ± 2.80
Tea	Alliance, Nebr.	KAN—DO	6/20	ND	ND	231 ±63	19.90 ±1.20	400 ±14
Tea, brewed			6/20	ND	ND	169 ±80	16.10 ±1.40	35.9 ± 4.30
Tea, loose	Beloit, Wis.	MIN—DO	7/10	ND	ND	289 ±63	20.50 ±1.20	497 ±15
Average, $\bar{x}$ Tea						296.2	20.5	430.3
Tea, brewed[e]						196.7	16.1	40.3
$2S_{\bar{x}}$, among Tea						47.8	0.72	91.9
Tea, brewed						37.9	0.50	12.0
$2\sigma_{\bar{x}}$, counting error Tea						16.7	0.33	5.9
Tea, brewed						26.3	0.48	1.3
n Tea						12	12	6
Tea, brewed						7	7	11

See footnotes at end of table.

Table 2g. Radionuclides in imported foods, cocoa

Food type and treatment or condition	Collection site	Collecting district or field office	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (gK/kg)	^{90}Sr (pCi/kg)
Cocoa	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	140 ±51	18.00 ±1.10	94.00 ±6.60
Cocoa	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	163 ±46	19.13 ± .60	61.05 ±5.48
Cocoa	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	144 ±43	16.11 ± .91	66.00 ±5.00
Cocoa	Atlanta, Ga.	ATL—FO	2/26	ND	ND	121 ±23	18.41 ± .96	59.00 ±4.00
Cocoa	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	128 ±42	17.6 ± .94	63.60 ±3.90
Cocoa	Lafayette, La.	NOL—DO	3/12	ND	ND	124 ±41	17.70 ± .90	65.90 ±3.60
Cocoa	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	125 ±41	17.10 ± .90	58.20 ±3.70
Cocoa	N. Massapequa, N.Y.	NYK—DO	4/24	ND	ND	95 ±43	16.80 ± .90	70.30 ±5.00
Cocoa	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	ND	17.30 ± .90	72.70 ±4.90
Cocoa mix	New Britain, Conn.	BOS—FO	6/11	ND	ND	66 ±37	10.3 ± .70	36.70 ±2.90
Cocoa	Alliance, Nebr.	KAN—DO	6/20	ND	ND	148 ±44	16.50 ± .90	62.90 ±3.70
Cocoa	Beloit, Wis.	MIN—DO	7/10	ND	ND	147 ±44	17.60 ± .90	69.00 ±4.00
Average, $\bar{x}$						127.4	16.9	64.9
2 $S_{\bar{x}}$, among						16.4	1.3	7.5
2$\sigma_{\bar{x}}$, counting error						12.6	0.3	1.3
n						11	12	12

See footnotes at end of table.

Table 2h. Radionuclides in imported foods, cashew nuts

Food type and treatment or condition	Collection site	Collecting district or field office	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (g K/kg)	^{90}Sr (pCi/kg)
Cashews	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	89 ±27	5.57 ±0.50	5.40 ±0.90
Cashews	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	65 ±24	6.42 ± .50	5.70 ± .98
Cashews	Bakersfield, Calif.	SAN—FO	2/13	ND	ND	141 ±27	6.52 ± .50	25.00 ±2.00
Cashews	Atlanta, Ga.	ATL—FO	2/26	ND	ND	61 ±25	5.72 ± .46	8.20 ±2.00
Cashews, canned	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	72 ±42	5.41 ± .45	8.90 ±1.80
Cashews, canned	Lafayette, La.	NOL—DO	3/12	ND	ND	82 ±24	5.96 ± .45	5.30 ±1.00
Cashews	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	28 ±26	5.80 ± .50	4.00 ±1.00
Cashews	Plainview, N.Y.	NYK—DO	4/25	ND	ND	189 ±27	6.06 ± .47	25.20 ±2.10
Cashews	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	61 ±26	6.00 ± .50	4.80 ±1.20
Cashews	New Britain, Conn.	BOS—FO	6/11	ND	ND	36 ±25	5.93 ± .47	1.59 ± .70
Cashews	Alliance, Nebr.	KAN—DO	6/20	ND	ND	80 ±28	6.40 ± .50	3.96 ± .98
Cashews	Beloit, Wis.	MIN—DO	7/10	ND	ND	35 ±27	5.60 ± .50	5.50 ±1.00
Average, $\bar{x}$						78.3	5.95	8.63
2 $S_{\bar{x}}$, among						26.6	0.21	4.57
2$\sigma_{\bar{x}}$, counting error						8.0	0.14	0.40
n						12	12	12

[a] Country of origin is given only if known.
[b] See figure 1.
[c] The g K/kg levels of stable potassium in commodities are computed from the potassium-40 activity. Potassium-40 occurs in nature to the extent of 0.011 percent of total potassium
[d] $2S_{\bar{x}}$ among $= 2\sqrt{S^2/n}$, "two standard deviations of the estimate of the mean, $\bar{x}$."
[e] $2\sigma_{\bar{x}}$ counting error $= \frac{2\sqrt{\Sigma\ (\text{counting error})^2}}{n}$
[f] The specific activity (pCi/kg) of brewed coffee was normalized to the dry weight of the sample.
[g] The specific activity (pCi/kg) of brewed tea was normalized to the dry weight of the sample.

ative assumptions, the levels of cesium-137 and strontium-90 found in percolated coffee are well within Range I of the guides. In the case of tea, all brewed samples are within Range I and II of the guides for both cesium-137 and strontium-90.

All 12 samples of cocoa had strontium-90 levels within Range II of the guides, while cesium-137 fell within Range I. In the case of cashew nuts, all samples were within Range I for cesium-137 and only two samples showed levels of strontium-90 in Range II. In all cases where Range II levels were found in individual foods, corrections for their relative percentage

Table 3. Radionuclides in total diet, market basket composites

Composite number[a]	Commodity type	Collection site	Collecting district office	Collection date (1973)	^{131}I (pCi/kg)	^{103}Ru (pCi/kg)	^{137}Cs (pCi/kg)	^{40}K (pCi/kg)	^{90}Sr (pCi/kg)
1	Dairy products	Carson City, Nev.	SAN—DO	10/30	ND	ND	ND	1.82 ±0.30	3.2 ±0.54
2	Meat, fish, poultry	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	ND	2.45 ± .40	0.77 ± .72
3	Grain and cereal products	Odessa, Tex.	Dallas—DO	2/21	ND	ND	ND	1.76 ± .63	9.40 ±2.10
4	Potatoes	Lafayette, La.	NOL—DO	3/12	ND	ND	ND	5.09 ± .42	11.2 ±1.20
5	Leafy vegetables	Jersey City, N.J.	BAL—DO	4/ 9	ND	ND	ND	1.90 ± .50	4.80 ±1.60
6	Legume vegetables	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	ND	2.45 ± .42	6.35 ±1.02
7	Root vegetables	Rochester, N.Y.	Buffalo—DO	6/ 4	ND	ND	ND	2.44 ± .64	8.88 ±2.12
8	Garden fruits	Beloit, Wisc.	MIN—DO	7/10	ND	ND	ND	2.06 ± .30	4.00 ± .80

[a] See appendix A.

in the diet would yield a total diet well within Range I.

These findings are further supported by data reported for the eight total diet composites presented in table 3. No iodine-131, ruthenium-106, nor cesium-137 were found within detectable limits of the methods. The levels for strontium-90 were within Range I of the guides for all total diet composites. These data are indicative of the "dilution effect" on the radionuclide levels as a result of the normal preparation of foods usual to the family household.

Summary

As the agency responsible for the wholesomeness of the nation's food supply, the FDA has instituted a monitoring program for radionuclides in the nation's total diet and selected import food commodities.

The radionuclide levels found in the total diets analyzed in Fiscal Year 1973 are within Range I of the appropriate guidelines, indicating the need for continued surveillance only at the present level.

The levels of radionuclides found in the limited types of edible imported commodities are low enough such that their contribution to the total diet would not be expected to raise the levels of these radionuclides above Range I of the guides. Data derived from this program will continue to be evaluated and compared with the FRC Guidelines for radionuclides in foods as the reference point in any possible regulatory action that may be necessary.

Acknowledgement

The able asistance of Dr. R. C. Bailey of the Division of Mathematics, BF, FDA in making the statistical evaluation of the data is deeply appreciated.

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Total diet market basket

Appendix A

Commodity	Quantity		Equivalent weight (g)
I. Dairy products:			
Milk, fresh fluid	9 quarts	8 fluid ounces	
Evaporated milk		7 fluid ounces	
Nonfat dry milk		2 ounces	57
Ice cream	1 quart	6 fluid ounces	
Cottage cheese		6 ounces	170
Processed cheese (American)		4 ounces	114
Natural cheese		3 ounces	85
Butter		7 ounces	199
Margarine		10 ounces	284
Skim milk	1 pint	3 fluid ounces	
II. Meat, fish and poultry:			
Roast beef		14 ounces	398
Ground beef (chuck)		9 ounces	256
Pork chops	1 pound	1 ounce	483
Bacon		7 ounces	199
Chicken (one whole eviscerated fresh or frozen)	2 pounds	1 ounce	937
Fish fillet (fresh or frozen)		7 ounces	199
Tuna or salmon (canned)		4 ounces	114
Luncheon meat		12 ounces	341
Frankfurters		7 ounces	199
Liver, beef		4 ounces	114
Eggs, large		14 each	
Cured ham (not canned)		9 ounces	256
Round steak (beef)	1 pound	13 ounces	824
Veal, chops or cutlets		4 ounces	114
Lamb, roast		4 ounces	114
Raw shrimp (fresh or frozen)		2 ounces	57
III. Grain and cereal products:			
Flour, general purpose		8 ounces	227
Pancake mix		1 ounce	28
Corn flakes		5 ounces	142
Shredded wheat or wheat cereal		3 ounces	85
Rice flakes or puffed rice		2 ounces	57
Oatmeal		5 ounces	142
Rice		13 ounces	369
Macaroni		15 ounces	426
White bread, enriched	5 pounds	11 ounces	2 584
Whole wheat bread		3 ounces	85
Rolls (sweet, cinnamon, Bismarcks, etc.)		8 ounces	227
Snack item (pretzels, corn chips, crackers, etc.)		10 ounces	284
Cookies, plain (w/o nuts or chocolate)	1 pound	2 ounces	511
Buns, frankfurter or hamburger		7 ounces	199
Pie crust (fruit filling-IX)		7 ounces	199
Cake mix		5 ounces	142
Wheat cereal, uncooked		2 ounces	57
Corn (raw)		13 ounces	369
Corn (canned)		13 ounces	369
Corn (frozen)		13 ounces	369
IV. Potatoes:			
Potatoes, white			
(bake 1/2)	3 pounds	10 ounces	1 647
(boil 1/4)	1 pound	13 ounces	824
(fry 1/4)	1 pound	13 ounces	824
Potato chips		6 ounces	170
Frozen french fries		6 ounces	170
Sweet potatoes or yams (fresh)		1 ounce	28
Sweet potatoes or yams (canned)		1 ounce	28
V. Leafy vegetables:			
Spinach, collard or mustard greens (raw)		6 ounces	170
Spinach, collards or mustard greens (frozen)		6 ounces	170
Spinach, collards or mustard greens (canned)		6 ounces	170
Celery (raw)		5 ounces	142
Lettuce (raw)	1 pound	3 ounces	540
Cabbage (raw 1/2)		1.5 ounces	43
Cabbage (boil 1/2)		1.5 ounces	43
Broccoli (fresh)		2 ounces	57
Broccoli (frozen)		2 ounces	57
Asparagus (fresh)		5 ounces	142
Asparagus (frozen)		5 ounces	142
Asparagus (canned)		5 ounces	142
VI. Legume vegetables:			
Peas (raw)		10 ounces	284
Peas (canned)		10 ounces	284

Total diet market basket—continued

Commodity	Quantity		Equivalent weight (g)
VI. Legume vegetables:			
Peas (frozen)		10 ounces	284
Green beans (raw)		10 ounces	284
Green beans (canned)		10 ounces	284
Green beans (frozen)		10 ounces	284
Beans with pork (canned)	1 pound	3 ounces	540
Lima beans (frozen)		1 ounce	28
VII. Root vegetables:			
Carrots (raw)		10 ounces	284
Carrots (canned)		10 ounces	284
Onions, dry (raw 1/2)		5 ounces	142
Onions, dry (boil 1/2)		5 ounces	142
Beets without tops (raw)		4 ounces	114
Beets without tops (canned)		4 ounces	114
Green onions		3 ounces	85
VIII. Garden fruits:			
Green peppers (raw)		4 ounces	114
Tomatoes (fresh)		10 ounces	284
Tomatoes (canned)		7 ounces	199
Cucumbers (raw)		6 ounces	170
Catsup		3 ounces	85
Pickles		4 ounces	114
Vegetable soup (canned)	1 pound		454
Tomato soup (canned)		2 ounces	57
IX. Fruits:			
Fruit filling from pie			
Oranges (fresh)	1 pound	2 ounces	511
Citrus juice (frozen concentrate)		4 fluid ounces	
Bananas	1 pound	5 ounces	596
Raisins		1 ounce	28
Peaches (fresh)		6 ounces	170
Peaches (canned)		6 ounces	170
Apples (fresh)	1 pound	4 ounces	568
Strawberries (raw, fresh)		3 ounces	85
Strawberries (frozen)		3 ounces	85
Citrus juice (canned)		13 fluid ounces	
Citrus juice (fresh)		13 fluid ounces	
Prunes		1 ounce	28
Grapefruit		9 ounces	256
Fruit juice, noncitrus (canned)		9 fluid ounces	
Apricots (raw)		1 ounce	28
Apricots (canned)		1 ounce	28
Cherries (raw)		1 ounce	28
Cherries (canned)		1 ounce	28
Grapes (raw)		2 ounces	57
Pears (raw)		3 ounces	85
Pears (canned)		3 ounces	85
Pineapple (raw)		1 ounce	28
Pineapple (canned)		1 ounce	28
Rhubarb without tops (raw)		1 ounce	28
Watermelon (raw)	1 pound		454
Cantaloupe (raw)		4 ounces	114
Fruit cocktail		4 ounces	114
X. Oils, fats and shortening:			
Salad dressing-french		1 fluid ounce	
Salad dressing-mayonnaise		5 fluid ounces	
Salad dressing-salad		1 fluid ounce	
Shortening		12 ounces	341
Peanut butter		6 ounces	170
XI. Sugar and adjuncts:			
Sugar, white	1 pound	5 ounces	596
Jelly		½ ounces	57
Pudding mix		3 ounces	85
Syrup, blended		1 ounce	
Jam		1 ounce	28
Candy bars		7 ounces	199
Baking powder		1/2 ounce	14
Salt		3 ounces	85
Vinegar		2 ounces	
XII. Beverages:			
Tea leaves		1 ounce	28
Coffee, ground		6 ounces	170
Cocoa		2 ounces	57
Cola soft drink		25 ounces	
Noncola soft drink		36 ounces	
Coffee, instant		1 ounce	28
Drinking water		8.5 liters	

[a] All weights indicated are raw or unprocessed weights. The actual weight of cooked or prepared food would be less in such items as meats and vegetables or fruits which are normally peeled and cooked before consumption.

SECTION I. MILK AND FOOD

Milk Surveillance, May 1974

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations: 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State Health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Research and Development Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reports in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131: (96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137: (53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89: (29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90: (32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are reported routinely in *Radiation Data and Reports.* The relationship between the

Table 2. Concentrations of radionuclides in milk for May 1974 and 12-month period, June 1973 through May 1974

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	NA	3	0	3
Alaska:	Palmer [c]	P	NS	4	NS	2
Ariz:	Phoenix [c]	P	NA	0	12	1
Ark:	Little Rock [c]	P	NA	13	13	2
Calif:	Los Angeles [c]	P	NA	0	0	0
	Sacramento [c]	P	NA	0	15	2
	San Francisco [c]	P	NA	0	0	0
	Del Norte	P	10	9	10	4
	Fresno	P	0	1	0	1
	Humboldt	P	4	2	0	0
	Los Angeles	P	0	1	0	2
	Mendocino	P	4	2	0	2
	Sacramento	P	2	1	0	2
	San Diego	P	1	1	0	1
	Santa Clara	P	0	1	0	2
	Shasta	P	2	2	0	2
	Sonoma	P	4	2	0	3
Colo:	Denver [c]	P	NA	3	0	0
	East	R	NS	NA	NS	28
	Northeast	R	NA	NA	0	4
	Northwest	R	NS	NA	NS	3
	South Central	R	NS	NS	NS	NS
	Southeast	R	NA	NA	0	0
	Southwest	R	NA	NA	0	0
	West	R	NA	NA	NS	0
Conn:	Hartford [c]	P	NA	4	0	1
	Central	P	NA		NA	
Del:	Wilmington [c]	P	NA	8	16	3
D.C:	Washington [c]	P	NA	4	13	1
Fla:	Tampa [c]	P	NA	4	29	26
	Central	R	4	5	24	27
	North	R	5	6	14	12
	Northeast	R	5	6	21	26
	Southeast	R	5	5	34	45
	Tampa Bay area	P	4	4	19	25
	West	R	9	8	11	20
Ga:	Atlanta [c]	P	NA	4	14	2
Hawaii:	Honolulu [c]	P	NA	0	0	0
Idaho:	Idaho Falls [c]	P	NA	4	0	0
Ill:	Chicago [c]	P	NA	5	0	0
Ind:	Indianapolis [c]	P	NA	5	11	4
	Central	P	6	5	0	4
	Northeast	P	7	6	15	10
	Northwest	P	7	7	10	7
	Southeast	P	6	6	10	7
	Southwest	P	7	7	20	6
Iowa:	Des Moines [c]	P	NA	4	0	0
	Des Moines	P	6	5	0 (2)	0
	Iowa City	R	5	5	0	0
	LeMars	R	NS	NS	NS	0
	Little Cedar	R	6	6	0	0
Kans:	Wichita [c]	P	NA	6	0	1
	Coffeyville	P	4	6	0	7
	Dodge City	P	2	4	NS	7
	Falls City, Nebr	R	4	5	NS	8
	Hays	P	5	6	NS	4
	Kansas City	P	7	5	NS	5
	Topeka	P	3	6	10	6
Ky:	Louisville [c]	P	NA	5	11	2
La:	New Orleans [c]	P	NA	4	17	4
Maine:	Portland [c]	P	NA	8	15	12
Md:	Baltimore [c]	P	NA	8	16	3
Mass:	Boston [c]	P	NA	8	11	5
Mich:	Detroit [c]	P	NA	6	12	3
	Grand Rapids [c]	P	NA	7	0	1
	Bay City	P	9	10	0	2
	Charlevoix	P	10	9	0	2
	Detroit	P	7	9	0	0
	Grand Rapids	P	10	13	0	5
	Lansing	P	10	11	0	3
	Marquette	P	11	13	0	6
	Monroe	P	10	13	0	1
	South Haven	P	10	14	0	2
Minn:	Minneapolis [c]	P	NA	7	0	1
	Bemidji	P	9	7	0	0
	Duluth	P	13	15	0	15
	Fergus Falls	P	4	5	0	0
	Little Falls	P	16	15	0	24
	Mankato	P	6	5	0	0
	Marshall	P	NS	3	NS	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for May 1974 and 12-month period, June 1973 through May 1974—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—Continued						
Minn:	Minneapolis	P	10	9	0	0
	Rochester	P	4	6	0	0
Miss:	Jackson [c]	P	NA	8	15	5
Mo:	Kansas City [c]	P	NA	4	0	0
	St. Louis [c]	P	NA	8	0	1
Mont:	Helena [c]	P	NA	0	0	0
Nebr:	Omaha [c]	P	NA	0	0	0
Nev:	Las Vegas [c]	P	NA	8	0	0
N.H:	Manchester [c]	P	NA	9	0	5
N.J:	Trenton [c]	P	NA	4	0	1
N. Mex:	Albuquerque [c]	P	NA	0	0	0
N.Y:	Buffalo [c]	P	NA	5	0	0
	New York City [c]	P	NA	4	0	2
	Syracuse [c]	P	NA	6	14	2
	Albany	P	4	4	0	0
	Buffalo	P	6	5	0	0
	Massena	P	6	7	0	10
	New York City	P	7	6	0	0
	Syracuse	P	5	4	0	0
N.C:	Charlotte [c]	P	NA	9	11	5
	Asheville	P	0		0	
	Charlotte	P	0		13	
	Lexington	P	0		0	
	New Bern	P	NS		NS	
	Raleigh	P	0		0	
	Wilkesboro	P	0		0	
N. Dak:	Minot [c]	P	NA	6	0	0
Ohio:	Cincinnati [c]	P	NA	6	12	3
	Cleveland [c]	P	NA	7	0	2
Okla:	Oklahoma City [c]	P	NA	2	0	0
Oreg:	Portland [c]	P	NA	3	0	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia [c]	P	NA	5	0	2
	Pittsburgh [c]	P	NA	10	12	3
	Dauphin	P	4	5	0	0
	Erie	P	7	7	0	1
	Philadelphia	P	5	5	0	0
	Pittsburgh	P	7	6	0	0
R.I:	Providence [c]	P	NA	4	12	5
S.C:	Charleston [c]	P	NA	5	20	9
	Anderson–01	R	NS	7	NS	0
	Anderson–02	R	NS	6	NS	0
	Chapin	R	NS	7	NS	8
	Clemson	R	NS	8	NS	8
	Columbia	R	NS	7	NS	10
	Fairfield	R	NS	6	NS	11
	Hartsville–02	R	NS	6	NS	9
	Hartsville–03	R	11	13	15	13
	Lee County	R	7	7	14	9
	Oconee County	R	NS	7	NS	5
	Pickens	R	NS	7	NS	9
	Williston	R	7	7	14	15
	Winnsboro	R	NS	6	NS	15
	York–01	R	7	7	5	5
	York–02	R	5	5	0	0
S. Dak:	Rapid City [c]	P	NA	8	0	1
Tenn:	Chattanooga [c]	P	NA	6	12	3
	Knoxville	P	NA	0	0	2
	Memphis [c]	P	NA	6	11	3
	Chattanooga	P	9	8	0	2
	Clifton	R	12	9	0	1
	Fayetteville	R	8	9	16	3
	Kingston	R	11	9	20	2
	Knoxville	P	9	7	13	3
	Lawrenceburg	R	4	5	0	0
	Nashville	P	8	6	0	0
	Pulaski	R	5	6	0	0
	Sequoyah	R	NS	9	NS	0
Tex:	Austin [c]	P	NA	0	0	0
	Dallas [c]	P	NA	3	0	0
Utah:	Salt Lake City [c]	P	NA	1	0	0
Vt:	Burlington [c]	P	NA	5	0	3
Va:	Norfolk [c]	P	NA	6	0	1

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for May 1974 and 12-month period, June 1973 through May 1974—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
Wash: Seattle [c]	P	NA	0	15	1
Spokane [c]	P	NA	4	0	0
Benton County	R	0	0	0	0
Franklin County	R	NS	1	NS	0
Longview	R	6	5	11	8
Sandpoint, Idaho	R	6	5	0	1
Skagit County	R	11	4	15	1
W. Va: Charleston [c]	P	NA	8	0	1
Wisc: Milwaukee [c]	P	NA	3	0	1
Wyo: Laramie [c]	P	NA	0	0	1
CANADA:					
Alberta: Calgary	P	NA		0	5
Edmonton	P	NA		0	9
British Columbia: Vancouver	P	NA		14	11
Manitoba: Winnipeg	P	NA		0	9
New Brunswick: Moncton	P	NA		0	8
Newfoundland: St. John's	P	NA		0	12
Nova Scotia: Halifax	P	NA		0	7
Ontario: Ottawa	P	NA		0	5
Sault Ste. Marie	P	NA		0	13
Thunder Bay	P	NA		0	9
Toronto	P	NA		0	5
Windsor	P	NA		0	5
Quebec: Montreal	P	NA		0	5
Quebec	P	NA		NA	NA
Saskatchewan: Regina	P	NA		0	4
Saskatoon	P	NA		0	5
CENTRAL AND SOUTH AMERICA:					
Canal Zone: Cristobal [c]	P	NA	0	0	0
Chile: Santiago	P	0	0	0	1
Colombia: Bogota	P	3	1	0	0
Ecuador: Guayaquil	P	0	1	0	0
Jamaica: Mandeville	P	NS		NS	
Puerto Rico: San Juan [c]	P	NA	3	11	2
Venezuela: Caracas	P	0	0	0	0
PMN network average [d]		NA	5	5	2

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[d] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups,

averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for May 1974 and the 12-month period, June 1973 to May 1974. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for May 1974 were below the respective practical reporting levels, except for strontium-89 at Coffeyville, Kans: 10 pCi/liter and Topeka, Kans: 6 pCi/liter.

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137 for North Carolina for January through April 1974.

Strontium-90 monthly averages ranged from 0 to 16 pCi/liter in the United States for May 1974 and the highest 12-month average was 15 pCi/liter (Little Falls, and Duluth, Minn.) representing 7.5 percent of the Federal Radiation

Table 3. Concentrations of radionuclides in North Carolina milk,[a] January–April 1974

Location in North Carolina	Type of sample	Radionuclide concentration (pCi/liter)		
		Strontium-90	Iodine-131	Cesium-137
Asheville:	P			
January		(b)	NA	NA
February		(b)	NA	NA
March		(b)	NA	NA
April		(b)	(b)	(b)
Charlotte:	P			
January		(b)	NA	NA
February		(b)	NA	NA
March		(b)	35	(b)
April		(b)	(b)	(b)
Lexington:	P			
January		(b)	NA	NA
February		(b)	NA	NA
March		(b)	NA	NA
April		(b)	(b)	(b)
New Bern:	P			
January		(b)	NA	NA
February		(b)	NA	NA
March		(b)	NA	NA
April		(b)	(b)	(b)
Raleigh:	P			
January		(b)	NA	NA
February		(b)	NA	NA
March		(b)	NA	NA
April		(b)	(b)	(b)
Wilkesboro:	P			
January		(b)	NA	NA
February		(b)	NA	NA
March		(b)	(b)	(b)
April		(b)	NA	NA

[a] Strontium-89 and barium-140 were all below the minimum detectable limit.
[b] Below minimum detectable limit.
NA, no analysis.

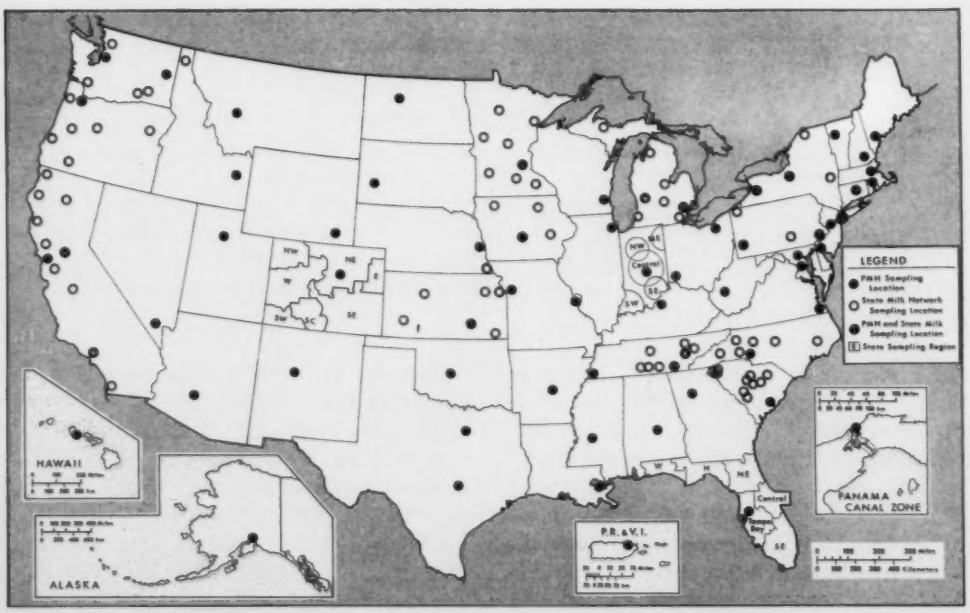

Figure 2. State and PMN sampling stations in the United States

Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 34 pCi/liter in the United States for May 1974, and the highest 12-month average was 45 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Radiologic Health Section
Environmental Control Component
California Department of Health

Radiation Protection Bureau
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

State Hygienic Laboratory
Medical Laboratories Building
Iowa City, Iowa

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Radiation Protection Branch
Division of Facility Services
North Carolina Department of Human Resources

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina Department of Health and Environmental Control

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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(5) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet	July 1971–December 1972	February 1974
Carbon-14 in Total Diet and Milk	1972–1973	November 1973
Strontium-90 in Tri-City Diets	1972	December 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
ERAMS Surface Water and Drinking Water Components	January–March 1974	August 1974
Florida	1970	April 1974
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1972	August 1974
Minnesota	July 1971–June 1972	March 1974
New York	1972	June 1974
North Carolina	1971	July 1974
Radiostrontium in Tap Water, HASL	1972	December 1973

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Radioactivity in Washington Surface Water[1] July 1971–June 1972

Washington State Department of Social and Health Services

Radioanalysis of surface water samples collected through the State is one of the major functions of the Washington State Department of Social and Health Services radiation surveillance program. Collection of these samples is performed by numerous cooperating agencies, including local water departments, county health districts, and other State agencies. Figure 1 shows the surface water sampling locations and code numbers.

All water is collected in 1-gallon cubitainers by grab sampling and is mailed to the State radiation laboratory in Seattle for analysis. A description of the analytical procedures used was presented in the August 1973 issue of *Radiation Data and Reports*. Some special analyses are performed by the National Environmental Research Center—Las Vegas (NERC-LV).

Analyses results of Columbia River samples are reported separately because of the unique isotopes present (table 1). The data reflect the more detailed laboratory analysis that Columbia River samples receive in order to document the significant isotopes present.

Concentrations of radioactivity in the Columbia River dropped below detectability limits following the shutdown on January 29, 1971,

[1] Summarized from "Environmental Radiation Surveillance in Washington State, Eleventh Annual Report, July 1971–June 1972."

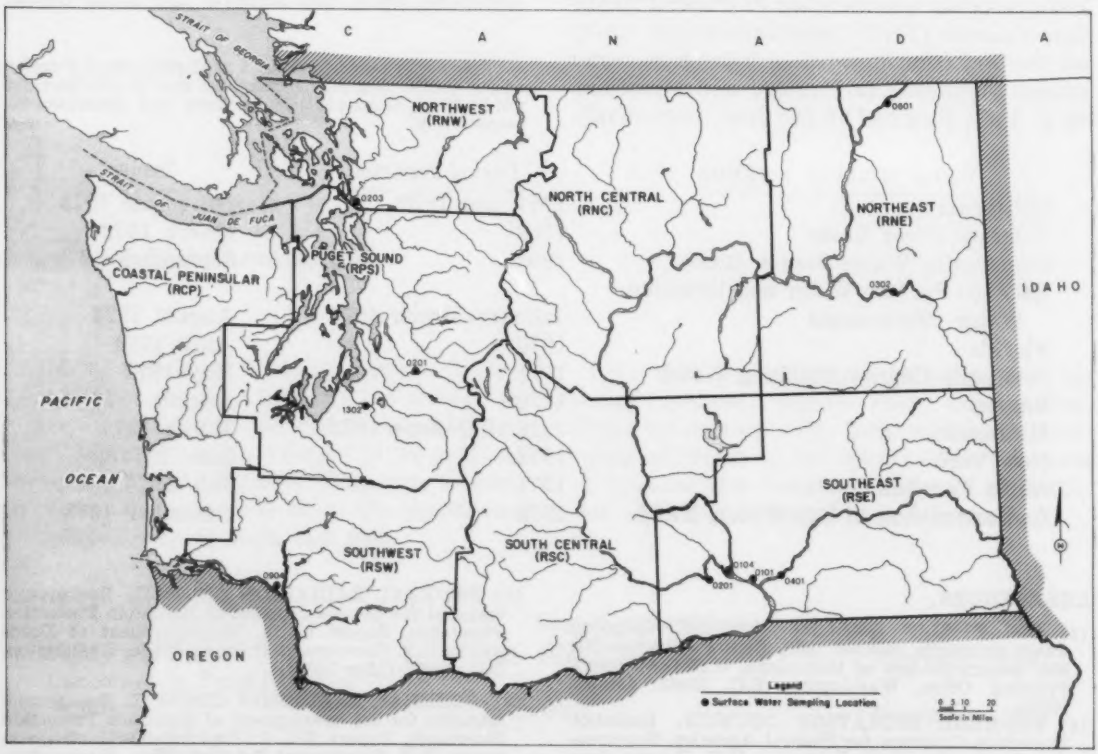

Figure 1. Washington surface water sampling locations with code numbers

Table 1. Monthly average radioactivity in Columbia River water, July 1971–June 1972

Sampling media	Radioactivity concentration (pCi/liter)											
	1971						1972					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Northport (code No. RNE 0601)												
Beta-particle:												
Tritium[a] [b]	700			1 200						870		
Richland (code no. RSE 0104)												
Beta-particle:												
Suspended [c]	<1	1	<1	1	1	1	<1	2	3	<1	2	4
Dissolved [c]	3	4	3	4	3	3	3	3	4	2	3	3
Total [c]	3	5	3	5	4	4	3	5	7	2	5	7
Phosphorus-32[b]	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	NA
Gamma-ray[b]												
Chromium-51	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Zinc-65	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Scandium-46	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pasco (code no. RSE 0101)												
Beta-particle:												
Suspended [c]	<1	<1	<1	<1	3	2	<1	<1	<1	2	<1	<1
Dissolved [c]	2	4	2	2	4	3	2	2	2	4	2	2
Total [c]	2	4	2	2	7	5	2	2	2	6	2	2
Phosphorus-32 [b]	<1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tritium[a] [b]	800			600			750			930		
Gamma-ray:[b]												
Chromium-51	<50	<50	<50	<50	<50	<50	NA	<50	<50	<50	<50	<50
Zinc-65	<10	<10	<10	<10	<10	<10	NA	<10	<10	<10	<10	<10
Scandium-46	<5	<5	<5	<5	<5	<5	NA	<5	<5	<5	<5	<5
Longview (code no. RSW 0904)												
Beta-particle:												
Suspended [c]	NS	NS	<1	<1	NS	NS	NS	NS	2	<1	<1	<1
Dissolved [c]	NS	NS	2	2	NS	NS	NS	NS	3	2	2	2
Total [c]			2	2					5	2	2	2
Phosphorus-32[b]	NS	NS	NA	NA	NS	NS	NS	NS	NA	NA	NA	NA
Gamma-ray:[b]												
Chromium-51	NS	NS	<50	<50	NS	NS	NS	NS	<50	<50	<50	<50
Zinc-65	NS	NS	<10	<10	NS	NS	NS	NS	<10	<10	<10	<10
Scandium-46	NS	NS	<5	<5	NS	NS	NS	NS	<5	<5	<5	<5

[a] Analyses performed by the U.S. Environmental Protection Agency, National Environmental Research Center-Las Vegas.
[b] Results extrapolated to date of collection.
[c] Strontium-yttrium calibration standard. Gross beta results >10 pCi/liter extrapolated to date of collection. All other gross beta results as of date of count (1–20 days after collection).
NS, no sample.
NA, no analysis.

of the KE and the N reactors at Hanford. The KE reactor was the last of eight original plutonium producing reactors. These eight reactors used single pass cooling systems for the reactor core and were the major sources of radioactivity entering the Columbia River. The N reactor was designed for both plutonium and electrical power production. It uses a double loop cooling system so that river water used for cooling does not enter the reactor core. Its contribution of radioactivity to the river in comparison with the reactors using single pass cooling is negligible.

This was confirmed in July 1971 when the N reactor was reactivated; no detectable change was observed in the radioactivity levels of the river. Although the tremendous flow of the Columbia tends to mask any effect of the reactor, its mode of operation is a significant improvement over the older reactors. The N reactor (800 MWe) was the first of the large scale nuclear power generating stations when it reached full design power in 1966. In September 1971, it reached a 15 billion KWh milestone, being the first single-reactor power station in the world to reach that goal.

Monthly averages of monitoring data from the Columbia River at Richland have been plotted to show the fluctuating concentrations encountered for the period 1964 through June 1972. Figures 2–5 show phosphorus-32, scandium-46, chromium-51, and zinc-65 concentrations, respectively.

Surface waters, other than the Columbia River are sampled to monitor the combined effect of background and of atmospheric fall-

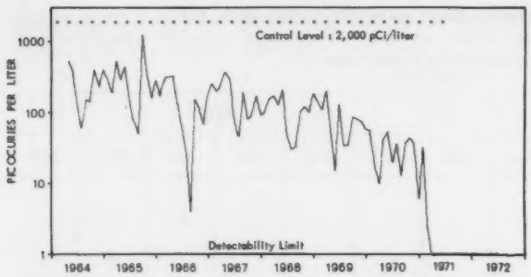

Figure 2. Phosphorus-32 monthly averages in Columbia river water, Richland, April 1964–June 1972

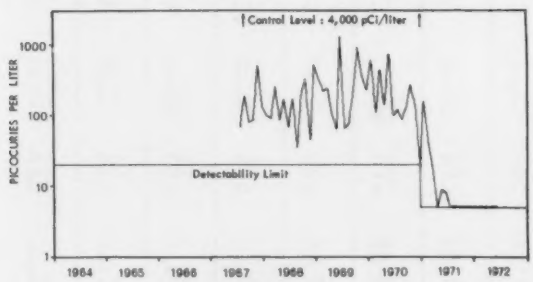

Figure 3. Scandium-46 monthly averages in Columbia river water, Richland, July 1967–June 1972

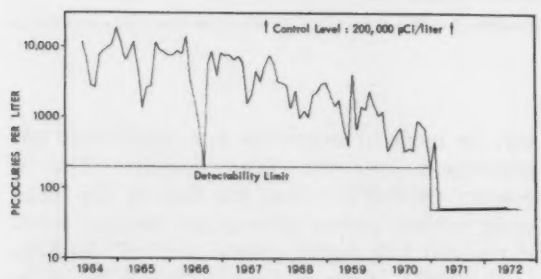

Figure 4. Chromium-51 monthly averages in Columbia river water, Richland, April 1964–June 1972

out (table 2). Figure 6 shows annual average and maximum gross beta activity in surface water samples for the period 1963 through 1972. The 1967 maximum of 26 pCi/liter on the plotted maximum values occurred in a Snake River sample resulting from fallout from the Chinese nuclear detonation of December 27, 1966. Other maximum values on the

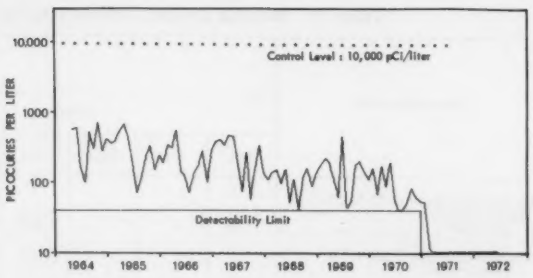

Figure 5. Zinc-65 monthly averages in Columbia river water, Richland, April 1964–June 1972

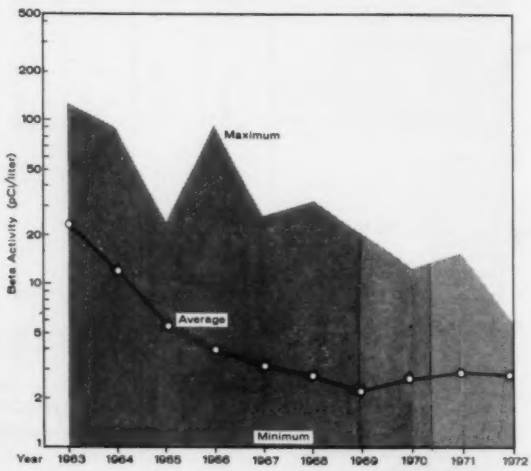

Figure 6. Average, maximum, and minimum beta radioactivity in surface waters, (excluding the Columbia river) 1963–1972

plot are associated with high turbidity samples.

Table 3 presents the individual sample results from the tritium analyses performed by the National Environmental Research Center—Las Vegas (NERC-LV).

Only three samples of salt water were collected and analyzed during this period. Laboratory efforts in this area have been directed toward developing capability for analyzing salt water for strontium-90. Past analyses have consisted of a gamma scan and a gross beta count. The data achieved by this method was judged practically useless: 1) the gamma scan of a 2 liter sample yielded no detectable results

Table 2. Beta radioactivity[a] in Washington surface water (except for Columbia River) July 1971–June 1972

Location and type of analysis	Radioactivity concentration (pCi/liter)											
	1971						1972					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Cedar River (PS 0201)												
Landsberg:												
Suspended	<1	<1	<1	NS	<1	<1	1	<1	<1	<1	<1	<1
Dissolved	1	<1	<1		<1	<1	2	<1	5	<1	<1	<1
Puyallup River (PS 1302)												
Puyallup:												
Suspended	<1	4	<1	NS	NS	2	<1	<1	1	2	<1	1
Dissolved	2	2	2			2	1	2	<1	4	1	1
Skagit River (NW 0203)												
Conway:												
Suspended	<1	<1	<1	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dissolved	2	2	1									
Snake River (SE 0401)												
Ice Harbor Dam:												
Suspended	NS	NS	NS	NS	NS	NS	NS	<1	2	NS	NS	NS
Dissolved								4	3			
Spokane River (NE 0302)												
Long Lake Dam:												
Suspended	<1	<1	<1	NS	NS	<1	<1	1	<1	<1	<1	<1
Dissolved	2	2	2			2	2	2	2	2	2	1
Yakima River (SE 0201)												
Kiona:												
Suspended	<1	<1	<1	NS	NS	<1	<1	<1	NS	1	2	1
Dissolved	3	4	4			3	2	2		1	2	2

[a] Strontium-yttrium calibration standard. Gross beta results <10 pCi/liter extrapolated to date at collection. All other gross beta results as of date of count (1–20 days after collection).
NS, no sample.

Table 3. Tritium[a] in Columbia River water, July 1971–June 1972

Sampling location	Collection date	Concentration (pCi/liter)
Northport	7/16/71	700
	10/ 5/71	1200
	4/26/72	870
Pasco	7/ 2/71	800
	10/ 6/71	600
	1/ 7/72	750
	4/ 5/72	930

[a] Analysis performed by National Environmental Research Center—Las Vegas (NERC-LV).

(other than natural potassium-40) because the concentrations present were far below the systems' detectability limits; 2) the gross beta data (either by a mixed fission product separation method or by a total gross beta method) were judged too ambiguous for use as a long-term baseline reference.

Another difficulty is the huge volume of salt water available for dilution and exchange, thus necessitating an extensive program of grab sampling to monitor average concentrations and trends. Therefore, future sampling of salt water will be restricted to approved reactor sites or to other specialized local situations.

The three salt water samples analyzed for strontium-90 yielded results of: <0.5, 0.5, and 1.8 pCi/liter.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
July 1970–June 1971	August 1973

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports*.

Network	Period	Issue
Fallout in the United States and other areas	1972	August 1974
Krypton-85 in air	July 1970–1972	March 1974
Mexican air monitoring program	July–December 1973	May 1974

1. ERAMS Gross Radioactivity and Deposition Component May 1974

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973, was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Gross Radioactivity and Deposition Component is a restructuring of the previous Radiation Alert Network (RAN). Sampling stations were relocated (figure 1) to more closely monitor the potential sources of environmental radioactivity and to provide the means for obtaining the maximum population coverage. The component consists of 74 sampling stations, 55 of which are on standby status and can be activated when the need arises. The remaining 19 stations collect air particulates continuously with the filters being changed one or two times per week. Most of the stations are operated by State or local health department personnel.

The station operators perform gross beta radioactivity "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples, which are collected concurrently at the air sampling stations, are sent to the Eastern Environmental Radiation Facility for laboratory gross beta radioactivity analyses. All field estimate results are reported to the appropriate Environmental Protection Agency officials by mail or telephone depending on the levels found. A com-

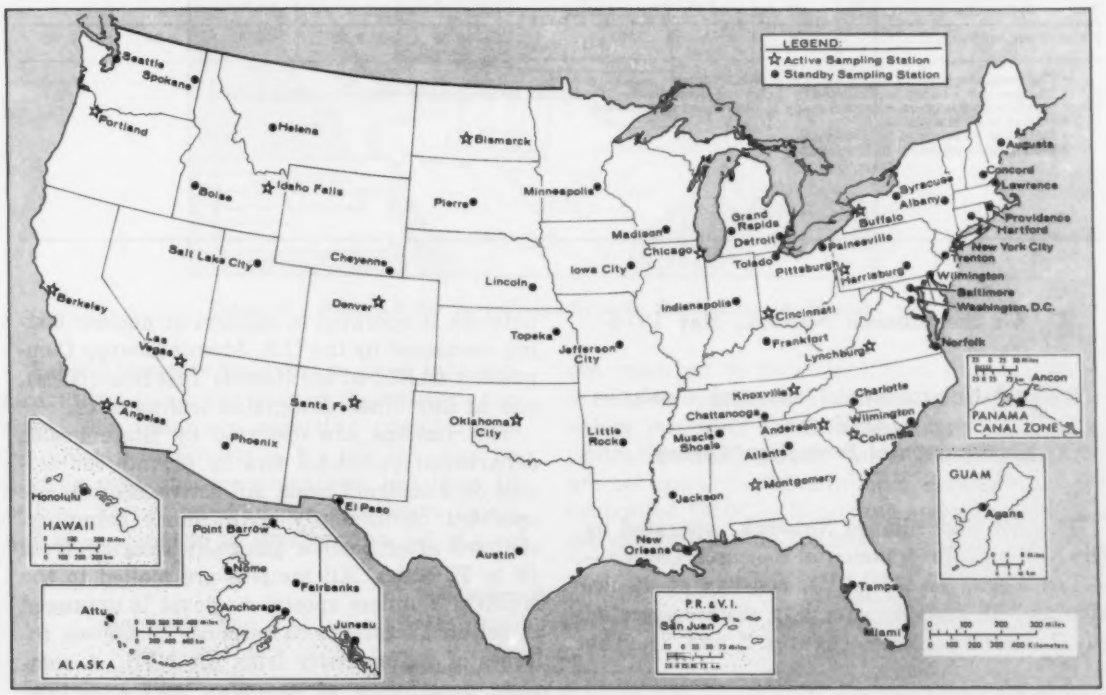

Figure 1. ERAMS Gross Radioactivity and Deposition Component sampling locations

pilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during May 1974.

Table 1. Gross beta radioactivity in surface air and precipitation, May 1974

Station location [a]		Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation	
			5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
			Maximum	Minimum	Average [b]	Maximum	Minimum	Average [b]	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	9	1	0	1	0.34	0.08	0.19	50	0.36
Calif:	Berkeley	9	0	0	0	.16	.07	.12		
	Los Angeles	9	1	0	1	.25	.14	.19		
Colo:	Denver	9	2	1	1	.55	.22	.38	1	.11
Idaho:	Idaho Falls	9				.42	.14	.29	22	.67
Ill:	Chicago	5	4	1	2	.26	.06	.16		
Ind:	Indianapolis [c]	7	0	0	0	.26	.07	.18		
Nev:	Las Vegas	9	1	1	1	.39	.23	.31		
N.Mex:	Santa Fe	2	1	1	1	.30	.28	.29	14	.24
N.Y:	Buffalo	9	1	0	0	.34	.11	.20	2	.04
	New York City	[d]								
N.Dak:	Bismarck	9	2	0	1	.20	.05	.14	100	1.65
Ohio:	Columbus [e]	2	1	1	1	.29	.20	.24		
Okla:	Oklahoma City	0								
Oreg:	Portland	14	0	0	0	.27	.02	.10	44	.33
Pa:	Harrisburg [f]	13	1	0	1	.36	.12	.21		
S.C:	Anderson	[d]								
	Columbia	9	1	0	1	.34	.16	.23	46	.39
Tenn:	Knoxville	[d]								
Va:	Lynchburg	[d]								
Network summary		124	4	0	1	0.55	0.02	0.22	35	0.47

[a] The remaining stations are on standby status.
[b] The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.
[c] Standby station operated continuously at the request of the State.
[d] Station to be established.
[e] Station to be relocated to Cincinnati.
[f] Station to be relocated to Pittsburgh.

2. Air Surveillance Network, May 1974

National Environmental Research Center—Las Vegas
Environmental Protection Agency

The Air Surveillance Network,[1] operated by the National Environmental Research Center——Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged after periods generally ranging from 48 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

[1] This network is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

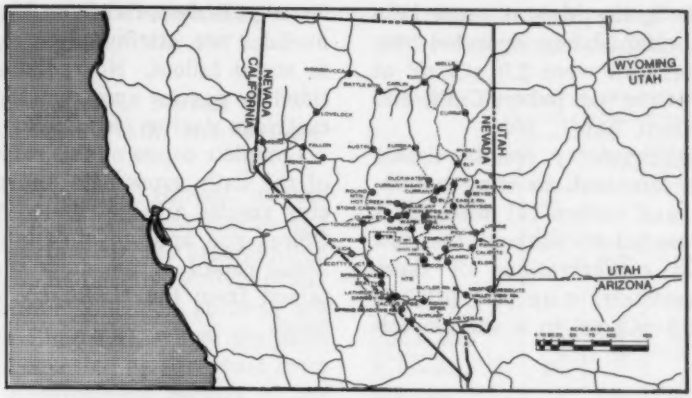

Figure 2. NERC-LV Air Surveillance Network Stations in Nevada

Figure 3. NERC-LV Air Surveillance Network Stations outside Nevada

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m³. For reporting purposes, concentrations less than 1.0 pCi/m³ are reported to one significant figure, and those equal to or greater than 1.0 pCi/m³ are reported to two significant figures. For averaging purposes individual concentration values less than the minimum detectable concentration (0.03 pCi/m³ for a 700 m³ sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are as follows:

Concentration (pCi/m³)	Reported value of concentration above MDC (pCi/m³)	Reported value of concentration below MDC (pCi/m³)
<0.05	<0.1	<0.1
≥ 0.05 <0.15	0.1	<0.1
≥ 0.15	As calculated and rounded	$<$ calculated MDC

As shown by table 2, the highest gross beta concentrations at continuously operated stations within the network were 2.0 pCi/m³ at Bishop, Calif, 1.8 pCi/m³ at Baker, Calif, and 1.5 pCi/m³ at Currant Ranch, Nev.

From gamma spectrometry results, fission products in varying combinations of zirconium-95, ruthenium-106 and cerium-141 were identified on filters collected throughout the network. The highest concentrations of these radionuclides, respectively, were 0.76 pCi/m³, 1.1 pCi/m³, and 1.0 pCi/m³ in a sample collected at Bishop, Calif., on May 17. These radionuclides are attributed to seasonal variations in world fallout. No radionuclides were identified by gamma spectrometry on any charcoal cartridge during May 1974.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentrations in air, May 1974

Sampling location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average *
Ariz:	Kingman	14	1.0	0.4	0.6
	Seligman	14	.8	.2	.5
Calif:	Baker	14	1.8	<.1	.7
	Barstow	14	1.1	.2	.5
	Bishop	14	2.0	.4	.7
	Death Valley Junction	11	.9	.4	.6
	Furnace Creek	14	1.0	.4	.6
	Lone Pine	12	.8	.3	.4
	Needles	6	.9	.5	.6
	Ridgecrest	14	.9	.3	.5
	Shoshone	14	.7	.1	.5
Nev:	Alamo	14	.9	<.1	.5
	Austin	8	.6	.2	.3
	Beatty	14	.9	.3	.5
	Blue Eagle Ranch (Currant)	14	1.5	.2	.7
	Blue Jay	14	1.2	.3	.5
	Caliente	12	.7	.3	.5
	Currant Ranch	14	1.2	.2	.5
	Diablo	14	1.1	.3	.5
	Duckwater	14	.9	.1	.4
	Ely	14	1.0	<.1	.4
	Eureka	14	1.2	.2	.6
	Fallini's Twin Springs Ranch	13	1.3	.3	.6
	Goldfield	14	1.1	.2	.4
	Groom Lake	14	.7	<.1	.5
	Hiko	14	.9	<.1	.5
	Indian Springs	14	.5	.2	.4
	Las Vegas	19	.8	.1	.6
	Lathrop Wells	13	.7	.3	.5
	Lida	14	1.0	.2	.5
	Lund	12	.8	.2	.5
	Mesquite	14	.6	.3	.4
	Nyala	14	1.3	.3	.6
	Pahrump	14	.7	.1	.5
	Pioche	14	1.2	<.1	.5
	Round Mountain	14	1.3	.3	.5
	Scotty's Junction	13	1.1	.4	.6
	Stone Cabin Ranch	14	1.1	.1	.4
	Sunnyside	14	.8	<.1	.4
	Tonopah	14	1.2	.3	.5
	Tonopah Test Range	9	1.1	.3	.5
	Warm Springs	6	.8	.2	.5
	Warm Springs Ranch	15	.8	.2	.5
Utah:	Cedar City	3	.6	.4	.5
	Delta	14	1.0	.2	.5
	Garrison	14	.8	.3	.6
	Milford	13	.9	<.1	.5
	St. George	13	1.2	.3	.6

* Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported a <0.1.

3. Canadian Air and Precipitation Monitoring Program,[a] May 1974

Radiation Protection Bureau
Department of National Health and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

[a] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for May 1974 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, May 1974

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.15	0.08	0.12	11.2	0.6
Coral Harbour	4	.12	.08	.12	136.9	.7
Edmonton	4	.19	.14	.17	144.6	8.1
Ft. Churchill	NS				87.6	1.1
Fredericton	4	.16	.07	.12	30.5	2.4
Goose Bay	4	.07	.04	.06	69.3	2.7
Halifax	4	.10	.04	.07	75.7	7.8
Inuvik	4	.14	.07	.11	358.9	.9
Montreal	4	.11	.03	.07	69.8	7.3
Moosonee	4	.19	.04	.12	94.1	8.1
Ottawa	4	.14	.04	.09	80.5	9.8
Quebec	4	.15	.07	.11	36.9	26.5
Regina	4	.15	.06	.11	82.1	7.7
Resolute	4	.13	.07	.10	49.0	.9
St. John's, Nfld.	2	.13	.08	.11	58.0	6.3
Saskatoon	4	.13	.07	.10	67.0	7.0
Sault Ste. Marie	4	.22	.08	.15	91.7	4.9
Thunder Bay	4	.19	.06	.13	102.4	10.4
Toronto	NS				50.6	7.9
Vancouver	4	.13	.06	.10	11.7	1.4
Whitehorse	4	.14	.05	.10	148.6	5.7
Windsor	NS				57.8	4.7
Winnipeg	4	.10	.10	.14	38.9	6.1
Yellowknife	4	.12	.05	.09	121.7	3.5
Network summary	82	0.22	0.03	0.11	86.5	5.9

NS, no sample.

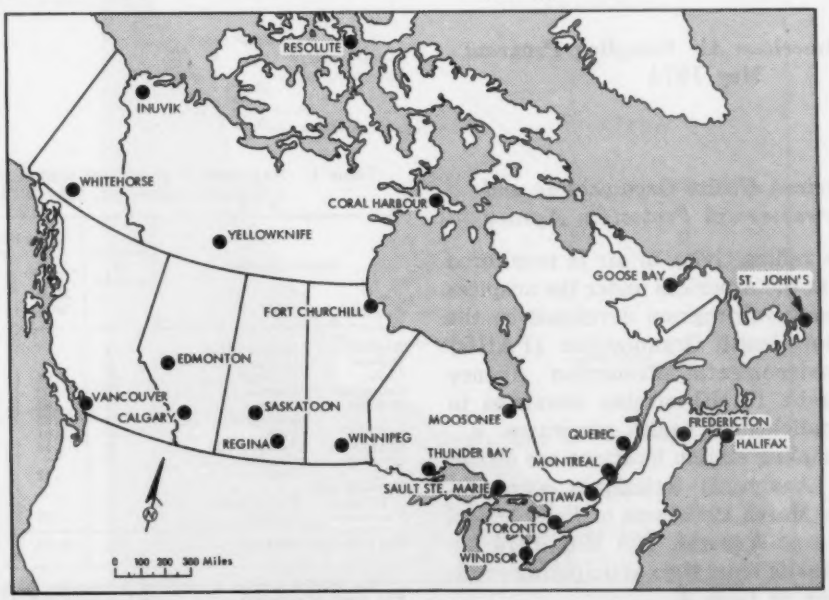

Figure 4. Canadian air and precipitation monitoring program

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(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

Figure 5. Pan American Air Sampling stations

4. Pan American Air Sampling Program May 1974

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The May 1974 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, May 1974

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	0			
Chile:	Santiago	30	0.04	0.00	0.01
Colombia:	Bogota	19	.02	.00	.00
Ecuador:	Cuenca	7	.01	.00	.00
	Guayaquil	19	.03	.00	.01
	Quito	13	.01	.00	.00
Guyana:	Georgetown	2	.15	.11	.13
Jamaica:	Kingston	0			
Peru:	Lima	21	.02	.01	.01
Trinidad and Tobago:	Port of Spain	0			
Venezuela:	Caracas	2	.15	.03	.08
Pan American summary		113	0.15	0.00	0.01

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

5. California Air Sampling Program May 1974

Radiologic Health Section
California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

One of the objectives of the program is to evaluate the possibility that fixed effluent sources contribute to particulate activity in the air. Consequently, data from continuous air samplers placed in proximity to nuclear facilities are compared with those from similar equipment in nearby communities and at several "background" stations.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health. The filters are analyzed for

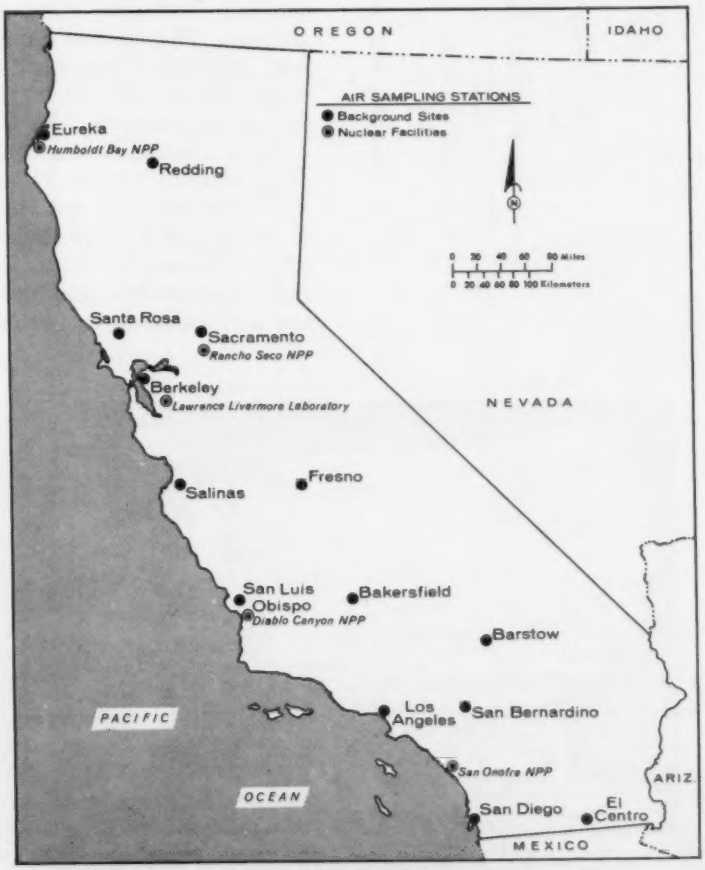

Figure 6. California air sampling program stations

gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. The monthly sample results are presented quarterly. Table 5 presents the gross beta radioactivity in air for May 1974.

Table 5. Gross beta radioactivity in California air, May 1974

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	20	1.38	0.26	0.69
Barstow	30	1.22	.20	.69
Berkeley	30	.57	.00	.29
Diablo Canyon Nuclear Power Plant	8	.29	.14	.23
El Centro	21	1.58	.25	.69
Eureka	20	.52	.08	.22
Fresno	21	1.03	.18	.53
Humboldt Bay Nuclear Power Plant	14	.37	.10	.24
Livermore	22	.69	.07	.35
Los Angeles	21	.65	.14	.35
Rancho Seco Nuclear Power Plant	13	.65	.24	.43
Redding	20	1.81	.30	.92
Sacramento	22	.47	.14	.28
Salinas	22	.48	.11	.26
San Bernardino	19	.76	.25	.46
San Diego	22	.90	.00	.35
San Luis Obispo	22	.60	.00	.30
San Onofro Nuclear Generating Station	4	.37	.21	.28
Summary	351	1.81	0.00	0.42

6. ERAMS Plutonium and Uranium in Air Component October–December 1973

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973 was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Plutonium and Uranium in Air Component is a restructuring of the Plutonium in Airborne Particulates Network, which was comprised of monthly plutonium analyses from selected Radiation Alert Network sampling stations. The current sampling stations have been reoriented towards fuel processing, fuel reprocessing, and other facilities using plutonium or uranium. The Plutonium and Uranium in Air Component consists of 19 air sampling stations (figure 7) and are taken from the 19 continuously operated sampling stations of the ERAMS Gross Radioactivity and Deposition Component. Plutonium-238, plutonium-239, uranium-234, and uranium-238 analyses are performed on a quarterly composite from

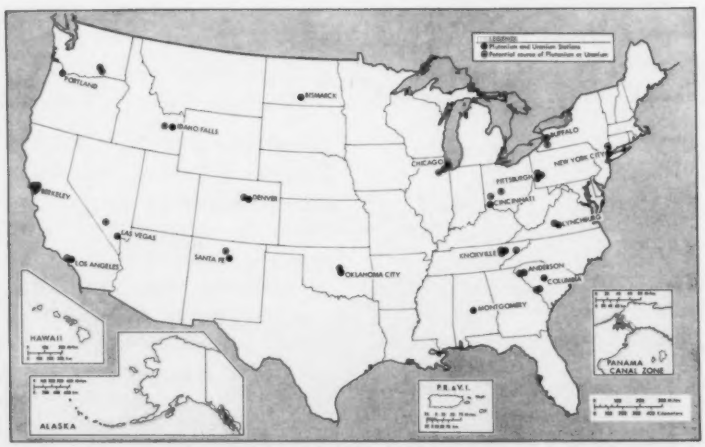

Figure 7. ERAMS Plutonium and Uranium in Air Component sampling locations

Table 6. ERAMS Plutonium and Uranium in Air Component, October–December 1973

Sampling location		Concentration [a] (aCi/m³ ±2σ)				^{239}Pu [b]	Potential sources of plutonium or uranium
		^{234}U	^{238}U	^{238}Pu	^{239}Pu	^{238}Pu	
Ala:	Montgomery	20.5±1.8	17.9±1.6	0.7±0.3	3.9±0.7	6±3	Background
Calif:	Berkeley	7.7± .9	5.7± .7	.5± .2	2.7± .6	5±3	General Electric Company San Jose, Calif. Lawrence Berkeley Laboratory Berkeley, Calif. Lawrence Livermore Laboratory Livermore, Calif.
	Los Angeles	26.5±2.5	29.9±2.8	1.6± .4	4.3± .7	3±1	Atomics International Canoga Park, Calif.
Colo:	Denver	93.4±6.6	99.5±7.0	2.1± .6	8.7±1.2	4±1	Rocky Flats Plant Golden, Colo.
Idaho:	Idaho Falls	[c]					National Reactor Testing Station Idaho Falls, Idaho
Ill:	Chicago	[c]					Argonne National Laboratory Lemont, Ill. Midwest Fuel Reprocessing Plant Morris, Ill.
Nev:	Las Vegas	230±14	124±8.0	2.3± .7	10.8±1.6	5±2	Nevada Test Site Las Vegas, Nev.
N. Mex:	Santa Fe	39.2±3.9	48.1±4.5	3.5±1.0	8.5±1.6	2±1	Los Alamos Laboratory Los Alamos, N. Mex.
N.Y:	Buffalo	99.0±6.7	92.0±6.3	.8± .3	4.4± .8	6±3	Nuclear Fuel Services West Valley, N.Y.
	New York City	[c]					Gulf United Nuclear Fuels Pawling, N.Y.
N. Dak:	Bismarck	23.7±2.0	21.7±1.8	.2± .1	2.4± .5	12±9	Background
Ohio:	Columbus [d]	89.2±6.9	78.3±6.2	0	9.5±1.7	----------	Battelle Columbus Laboratory Columbus, Ohio Mound Laboratory Miamisburg, Ohio
Okla:	Oklahoma City	NS					Kerr-McGee Cimarron Plant Crescent, Okla.
Oreg:	Portland	6.4±1.1	6.8±1.2	1.0± .4	2.5± .6	3±1	Hanford Laboratories Richland, Wash. Exxon Nuclear Richland, Wash.
Pa:	Harrisburg [e]	33.8±3.0	32.5±2.9	1.0± .4	8.9±1.3	9±3	Westinghouse Cheswick, Pa. NUMEC—Babcock & Wilcox Leechburgh, Pa.
S.C:	Anderson	[c]					Westinghouse Fuels Recycle Anderson, S.C. Savannah River Plant Aiken, S.C.
	Columbia	58.2±4.4	49.3±3.8	3.1± .7	5.3± .9	2±1	Allied Gulf Nuclear Fuel Services Barnwell, S.C.
Tenn:	Knoxville	[c]					NFS Fuels Fabrication Plant Erwin, Tenn. Oak Ridge National Laboratory Oak Ridge, Tenn. LMFBR Demo Site Oak Ridge, Tenn.
Va:	Lynchburg	[c]					Babcock & Wilcox Lynchburg, Va.
Average		60.6	50.5	1.4	6.0	5	

[a] Any concentration less than the 2σ error has been reported as zero.
[b] Ratio calculated from raw data before rounding
[c] Station to be established.
[d] Staton to be relocated at Cincinnati.
[e] Station to be relocated at Pittsburgh.
NS, no sample.

each of the 19 sampling stations by the Eastern Environmental Radiation Facility, Montgomery, Ala. The volume of the air sampled ranged generally between 25 000 to 40 000 m³ for each quarterly composite sample analyzed. The results from October–December 1973 are shown in table 6. The minimum detectable activities are 20, 15, 15, and 15 fCi per sample for plutonium-238, plutonium-239, uranium-234, and uranium-238, respectively.

Other coverage in *Radiation Data and Reports:*

Period	Issue
October–December 1972	June 1973
January–March 1973	May 1974
April–June 1973	June 1974
July–September 1973	September 1974

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Vertebrae, 1972[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since 1961, the strontium-90 content of human vertebrae has been measured by the Health and Safety Laboratory (HASL). In 1968, sampling in Chicago was discontinued. Data obtained from these programs have been used to construct models that attempt to explain the variation of strontium-90 concentrations in bone with age and time. The main purpose of the work is to provide estimates of the radiation dose to man that has resulted from the fallout from nuclear weapons tests. In attempting to construct the models it has become apparent that there are serious gaps in our knowledge of mineral metabolism, especially that of children. The survey data have therefore been used, at times, to gain some insight into the metabolism of strontium by children. This approach is very difficult because of the small numbers of specimens that are available and the absence of an exact knowledge of the diet of the children from whom specimens were obtained. Because it is unlikely that much direct experimental data from tracer studies on children will ever be available, we will be forced to rely on the indirect evidence from survey results to construct our models.

During 1972, 284 specimens of human vertebrae were analyzed, including 53 from children and 67 from adults obtained in New York City and 100 from children and 64 from adults obtained in San Francisco. A summary of the results of strontium-90 determinations is given in table 1.

Table 1. Strontium-90 to calcium ratios in human vertebrae, 1972

Age	Strontium-90 to calcium ratios (pCi ^{90}Sr/g Ca)	
	New York City	San Francisco
0–1 week		0.52 (57)
1–7		.67 (14)
0–2 months	1.38 (7)	
1–7		1.42 (12)
6	2.91 (1)	
1–2 years	3.35 (2)	.83 (1)
2–3	2.88 (1)	.52 (1)
3–4	2.65 (1)	.77 (2)
4–5	2.56 (3)	.89 (1)
5–6	1.83 (2)	.68 (1)
6–7		1.30 (2)
7–8	1.86 (1)	
8–9	1.46 (1)	
9–10	1.68 (1)	
10–11	1.91 (2)	
11–12	1.99 (1)	.82 (2)
12–13		.95 (1)
13–14	1.57 (1)	
14–15	1.76 (2)	
15–16	1.31 (1)	
16–17	1.64 (6)	.91 (2)
17–18	1.92 (3)	
18–19	1.93 (12)	1.63 (1)
19–20	1.77 (5)	1.51 (3)
20–30	1.61 (23)	.88 (2)
30–40	1.41 (7)	.86 (9)
40–50	1.11 (8)	.85 (12)
50–60	1.54 (12)	.74 (17)
60–70	1.34 (7)	.64 (15)
70–80	1.45 (6)	1.17 (7)
80–90	1.53 (4)	1.05 (2)

[a] Number in parentheses indicates number of samples.

The strontium-90 to calcium ratios for adults are relatively constant, as has previously been observed. The variations about the mean are typical of such survey measurements. The average values and standard deviations for adult vertebrae in 1972 were 1.39 ± 0.39 pCi/g Ca in New York and 0.82 ± 0.34 pCi/g Ca in San Francisco.

The strontium-90 to calcium ratios for children's bone show more variation than the adult values. Generally higher values were obtained

[1] Summarized from Fallout Quarterly Summary Reports, HASL-274 (July 1, 1972).

for children than adults in New York, but most values were within a factor of 1½ to 2 of the adult values. In San Francisco, the strontium-90 ratios for children had previously been slightly higher than for adults, and except for the 1–7 month old group, there is no longer any indication of higher values for children. Not a large number of samples were obtained during the year for the 1 to 20-year-age group. The highest value measured in New York vertebrae during 1972 was 4.18 pCi/g Ca for a 4-year-old child and in San Francisco, 2.82 pCi/g Ca for a 19-year-old.

The higher strontium-90 concentration values in New York bone correspond to greater dietary strontium-90 intake. The strontium-90 to calcium ratios in total diet in New York and San Francisco during 1972 were 10.6 pCi/g Ca and 3.6 pCi/g Ca, respectively (*1*). These ratios in diet have decreased an average of 6 to 7 percent per year during the past 2 years.

Bone model

An improved bone model was formulated to correlate the strontium-90 concentrations in diet and bone (*2*). The model as it applies to adult vertebrae is described by the equation:

$$B_n = cD_n + g\sum_{m=0}^{\infty} D_{n-m}e^{-m\lambda} \qquad (1)$$

where,

B_n = ^{90}Sr concentrations in vertebrae in the year n (pCi)

D_n = ^{90}Sr concentration in diet from midyear in the year n–1 to midyear in the year n (pCi)

c = short-term retention of ^{90}Sr in bone

g = long-term retention of ^{90}Sr in bone, and

$1 - e^{-\lambda}$ = effective removal rate for ^{90}Sr in bone including radioactive decay (yr^{-1}).

The formula describes a two compartment model, one compartment associated with short-term retention of strontium on bone surfaces and another compartment in which the strontium is more tightly retained in bone. The parameters c and g are independent and not related to the previously used concept of observed ratio, since retention can also be associated with processes other than new bone formation. The effective removal rate or turnover rate for strontium-90 in bone is related to the rate of bone remodeling, but since strontium-calcium discrimination and reutilization are not explicit in the model, the removal rate can be considered to provide only an upper limit estimate of the actual bone renewal rate. The factors c, g, and λ are constant for adults ($\geq$ age 20 years) but are age dependent for children.

Variations of the above bone model were investigated, such as the inclusion of an exponential in the short-term retention term. The best fit in this form, however, was with a very high order exponential, indicating essentially complete turnover of the short-term component during the course of a year.

The above formula for the bone model maintains a desired simplicity and yet gives adequate description of the year-to-year changes in strontium-90 content of bone. The values obtained for the model parameters allow reasonable interpretation.

Strontium-90 in adult vertebrae

The observed strontium-90 concentrations in adult vertebrae are shown in figure 1. Additional approximate values for the earliest years of contamination (1954–1959) in New York City from the data of Kulp and Schulert (*3*) have also been included. The adult data include only samples from individuals age 20 years or older in 1954, thus representing adult metabolism for the entire contamination period.

A definite decreasing trend in the observed values is apparent since 1965, corresponding to decreases in dietary strontium-90 intake. The relatively large standard deviations about the average values preclude extremely accurate determination of the actual decreases and thus the effective removal rates, however, these are becoming more firmly established as additional years of data accumulate during periods of decreasing strontium-90 levels in diet.

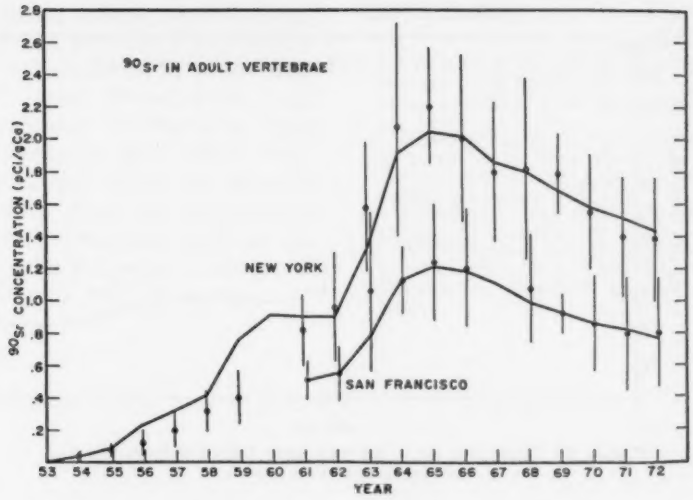

Figure 1. Strontium-90 in adult vertebrae—observations (points with standard deviations and bone model predictions, solid line)

From regression analysis of the measured New York City adult diet and vertebrae values through 1972 in the above bone model, one infers a turnover rate of strontium-90 from adult vertebrae of 20 percent per year. A turnover rate of 17 percent per year gives the best fit to the San Francisco adult data through 1972. The best fits to the observed data using the bone model are shown in figure 1.

The model shows peak strontium-90 concentrations in adult vertebrae in 1965, in agreement with observations. Subsequent decreases are achieved with a turnover rate which is reasonable, in view of the remodeling and diffusion processes occurring in bone. The bone model appears to be quite responsive to strontium-90 levels in diet and gives very satisfactory fits to the observed strontium-90 levels in vertebrae.

Strontium-90 in children's bone

The strontium-90 concentration in children's bone can be determined by the formula:

$$B_{i,n} = (c_i+g_i)\, D_{i,n} + [B_{i-1,n-1} - c_{i-1},\, D_{i-1,n-1}]\, e^{-\lambda_i} \qquad (2)$$

The bone model parameters are defined as before. The subscript i indicates the age dependence.

For the newborn, the strontium-90 concentration can be related empirically to the mother's diet. The strontium-90 to calcium ratio in bone of newborn varies from 0.1 to 0.2 times the strontium-90 to calcium ratio in diet of the mother during the year prior to the birth. An average of about 0.15 is obtained from the survey data.

From the regression results for children, one infers that a one compartment, single exponential model ($c_i = 0$) applies to children under age 8 years. The one compartment formulation of the above model closely corresponds to the previously used Rivera bone model (*4*). The undifferentiated nature of bone of young children and the relatively high bone renewal rates justify the one compartment treatment.

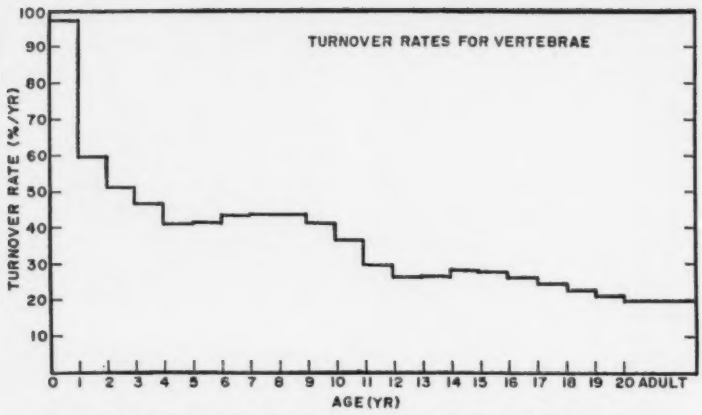

Figure 2. Turnover rates for vertebrae inferred from the two compartment bone models

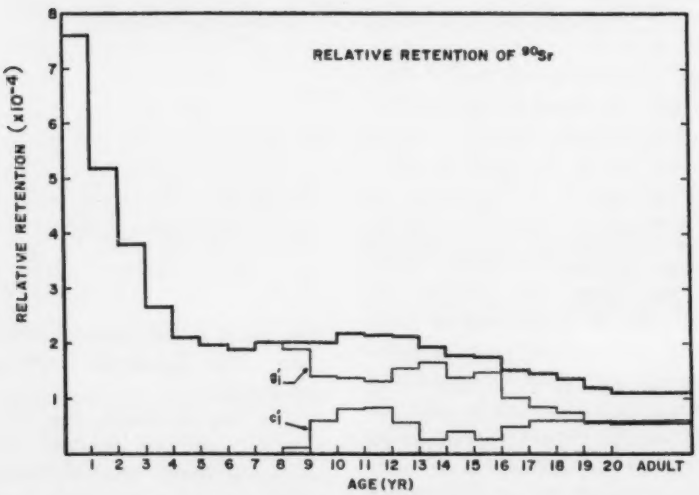

Figure 3. Retention of strontium-90 per gram skeletal calcium (the upper histogram is the total relative retention, c_1 is the short-term component and g_1 is the long-term component)

The strontium-90 turnover rates and relative retention as a function of age are shown in figures 2 and 3. The turnover rates reflect bone growth activity and are highest for the youngest children. Nearly 100 percent per year turnover rate is indicated for the 0–1 year age range. A relatively high turnover rate, about 40 percent, is maintained through the preteenage years. The values then decrease to the adult value.

The relative retention of strontium-90 in bone, shown in figure 3, is the fractional retention of the dietary strontium-90 intake (c_1+g_1) per gram of skeletal calcium. The highest efficiency for strontium-90 retention is obtained for the youngest children. Increased efficiency associated with increased growth is also indicated for children in the early teenage years.

The magnitude of the relative retention was

determined by assuming that vertebrae is representative of the entire skeleton. This assumption becomes less satisfactory for older children and adults. Initial estimates of body burden will be high and estimates at later times will be low, assuming less initial retention and slower turnover rates for compact bone. Integral results should be more representative for the entire skeleton, such as the cumulative dose results following a period of strontium-90 intake of 1 year or more.

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(3) KULP, J. L. and A. R. SCHULERT. Strontium-90 in man. Science 619:136 (1962).
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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the levels of environmental contaminants including radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required. The complete environmental monitoring reports are available from local AEC operations offices or from the National Technical Information Service at a nominal cost. The portions of these reports dealing with radioactivity are summarized for *Radiation Data and Reports.* Statements interpreting the radioactivity data are those of the USAEC contractors. The units for the data as reported in the individual reports have been converted from the format required by the AEC to that used by *Radiation Data and Reports.* The Environmental Protection Agency has not independently nor critically reviewed the data nor the conclusion derived therefrom.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental data follow for Portsmouth Gaseous Diffusion Plant and Shippingport Atomic Power Station.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Portsmouth Area Gaseous Diffusion Plant[a] January–December 1972

Goodyear Atomic Corporation
Piketon, Ohio

The Portsmouth Gaseous Diffusion Plant is owned by the U.S. Atomic Energy Commission and is operated by Goodyear Atomic Corporation, a subsidiary of the Goodyear Tire and Rubber Company. It is located in thinly populated, rural Pike County, Ohio, on a 16.2 km² site about 1.6 km east of the Scioto River Valley at an elevation about 37 m above the Scioto River flood plain. A map showing the plant size and its environs is presented in figure 1. The terrain surrounding the plant, except for the Scioto River flood plain, is marginal farm land and densely forested hills.

The principal process in the plant is the separation of uranium isotopes through gaseous diffusion. Ancillary processes include feeding material into and withdrawing material from the primary process; treatment of water for both sanitary and cooling purposes; decontamination of equipment removed from the plant for maintenance or replacement; recovery of uranium from various waste materials, such as decontamination solutions; and treatment of sewage wastes.

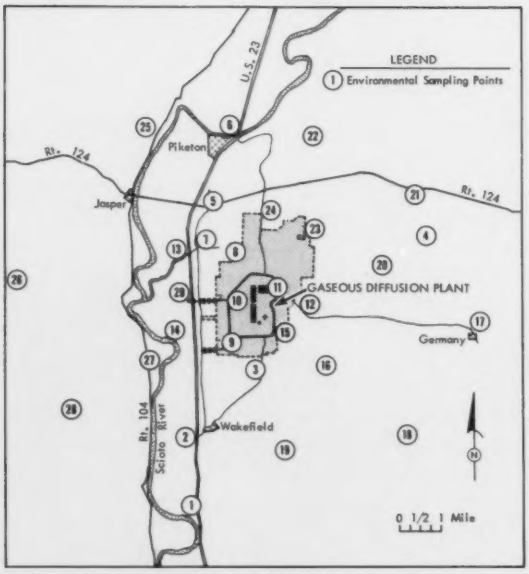

Figure 1. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

In the operation of a gaseous diffusion plant, as in the operation of any industrial plant, waste materials necessarily are generated as byproducts of the industrial processes. Since there is an ever present possibility that the wastes may contain environmental pollutants, including radioactive materials, the effluents from the various facilities are monitored carefully and frequently to assure that excessive quantities of pollutants and radioactive materials are not discharged into the environment. No streams from the plant are left unmonitored. Where necessary, treatment is provided to reduce concentrations to acceptable limits before the materials are discharged. In addition, water, air, and soil samples are collected routinely at many points both inside and outside the plant property to assure that the ambient environment has not been polluted with radioactive materials or other contaminants. Figure 1 shows the locations where samples normally are collected. This report describes the various environmental standards applicable to the Portsmouth Gaseous Diffusion Plant; the sampling, monitoring, and analytical procedures; and the extent of conformance with the standards.

Before July 1972, air samples were collected three times each week at four locations, identified as points 3, 12, 24, and 29 (figure 1). Each radioactivity sample, consisting of approximately 28 cubic meters of air, was passed through a Whatman #41 filter paper at about 0.56 cubic meter per minute. The material collected on the filter paper was analyzed for gross alpha and gross beta-gamma activities. In June, permanent sampling stations were installed at all four locations and in addition, a permanent sampling station was installed at location 28 in July. Air samples now are drawn through the filter paper, mounted on aperture IBM cards, at approximately 1.2 cubic meters per hour. The cards are changed once each week, after approximately 200 cubic meters of air are sampled.

[a] Data summarized from "Portsmouth Gaseous Diffusion Plant Environmental Monitoring Report—1972."

Table 1. Radioactivity in air, Portsmouth Plant, January–December 1972

Location	Number of samples	Alpha radioactivity concentration (fCi/m³)		Average as a percent of AEC standards[a]	Beta-gamma radioactivity concentration (pCi/m³)		Average as a percent of AEC standards[a]
		Maximum	Average		Maximum	Average	
3	93	113 ±113	16 ± 5	0.40	1.594 ±0.398	0.209 ±0.057	0.02
12	96	177 ±177	17 ± 7	.43	1.787 ± .447	.211 ± .059	.02
24	91	403 ±101	17 ±10	.43	3.429 ± .857	.266 ± .095	.03
28	22	16 ± 16	5 ± 3	.13	.097 ± .024	.041 ± .015	.00
29	90	113 ±113	14 ± 5	.35	5.088 ±1.272	.284 ± .130	.03

[a] The AEC radiation protection standard for alpha radioactivity in air—4 000 fCi/m³; beta-gamma radioactivity—1 000 pCi/m³; sensitivity of analysis for both alpha and beta radioactivity is 16.1 fCi/m³.

Table 2. Radioactivity in water, Portsmouth Plant, January–December 1972

Location	Number of samples	Water flow rate (m³/s)	Alpha radioactivity concentration (pCi/liter)		Average as a percent of AEC standards[a]	Number of samples	Beta-gamma radioactivity concentration (pCi/liter)		Average as a percent of AEC standards[a]
			Maximum	Average			Maximum	Average	
1	12	317.5	49.1 ± 25.0	7.7 ± 8.5	0.03	12	40.5 ± 2.8	6.8 ± 7.3	0.03
2	12	[b]	10.8 ± 5.0	4.1 ± 2.1	.01	12	ND	ND	
3	51	.011	40.1 ± 20.5	5.0 ± 2.0	.02	51	27.0 ± 1.9	6.7 ± 1.9	.03
4	12	[b]	5.0 ± 2.6	1.7 ± .9	.01	12	54.0 ± 3.8	7.5 ± 9.5	.04
5	12	[b]	17.6 ± 9.0	3.2 ± 3.1	.01	12	ND	ND	
6	44	317.5	9.9 ± 5.0	2.8 ± 1.1	.01	44	27.0 ± 1.9	3.7 ± 1.8	.02
7	18	.329	422.1 ±215.3	67.2 ±47.5	.22	18	639.0 ± 44.7	197.6 ±118.5	.99
8	18	.329	183.6 ± 93.6	54.3 ±25.9	.18	18	544.5 ± 38.1	10.1 ± 5.6	.84
10	51	.011	32.0 ± 16.3	5.4 ± 1.7	.02	51	103.5 ± 7.2	270.4 ±117.7	.05
11	51	.045	588.2 ±300.0	123.7 ±35.1	.41	51	2 313.0 ±161.9	8.3 ± 9.9	1.35
12	12	[b]	4.1 ± 2.1	1.4 ± .7	.005	12	54.0 ± 3.8	37.8 ± 21.6	.04
13	12	[b]	166.1 ± 84.7	39.3 ±36.7	.13	12	90.0 ± 6.3	6.2 ± 4.5	.19
14	17	317.5	40.5 ± 20.7	8.5 ± 5.5	.03	17	27.0 ± 1.9		.03

[a] The AEC radiation protection standard for alpha radioactivity in water—30 nCi/liter; beta-gamma radioactivity—20 nCi/liter; sensitivity of analysis' alpha radioactivity—0.5 pCi/liter; beta radioactivity—0.5 pCi/liter.
[b] Not measured.
ND, nondetectable.

Average alpha and beta-gamma radioactivity concentrations are summarized in table 1.

Two procedures are used for water sampling. Two-liter samples are taken monthly from the Scioto River and its tributaries, Little Beaver Creek, Big Beaver Creek, and Big Run. Composite samples are collected continuously (or at specific intervals) from the three principal drainage ditches serving the plant; sampling locations are identified on the map as points 3, 10, and 11. The composite samples are collected in 200-liter drums. Once each week, the water in the drums is mixed thoroughly, a 2-liter sample is withdrawn for analysis, and the drum is drained, cleaned, and installed again in the collection system. The 2-liter samples are analyzed for gross alpha and beta-gamma radioactivity. Radioactivity in water samples are shown in table 2.

External gamma radiation levels are measured routinely at locations 3, 12, 24, 28, and 29 to serve as indicators of background radiation. Measurements are made three times each week with a calibrated Geiger-Mueller tube at a distance of 1 meter above ground level. Average background rate for 1972 was 11.7 μR/h, which is not significantly different from the 1954 average rate, 11.9 μR/h. Background radioactivity is shown in table 3.

The data presented in the tables show clearly that radioactivity contamination of the environment is not a problem at the Portsmouth Gaseous Diffusion Plant. Maximum concentrations of alpha radioactivity in air, beta-gamma in air, alpha in water, and beta-gamma in water during 1972 were only 10.1 percent, 0.5 per-

Table 3. Background radiation, Portsmouth Plant January–December 1972

Location	Number of samples	Exposure rate [a] (μR/h)		Exposure [b] (mR)
		Maximum	Average	
3	113	24.3±3.6	12.0±0.6	105.1±5.3
12	113	26.0±3.9	11.2± .6	98.1±5.3
24	111	26.7±4.0	11.9± .6	104.2±5.3
28	42	19.8±3.0	11.6±1.0	101.6±8.7
29	110	21.4±3.2	11.8± .5	103.4±4.4

[a] Open-shield Geiger tube 0.9 meter above ground; limit of sensitivity—0.1 μR/h. Average background exposure rate for the Portsmouth Gaseous Diffusion Plant in 1954 was 11.9 μR/h, not significantly different from present rates.
[b] Total for the year.

cent, 2.0 percent, and 11.6 percent of the AEC standards, respectively. None of the averages was greater than 1.4 percent of the AEC standards. As may be seen in table 2, the only significant concentrations of radioactivity in water were found in samples taken downstream from the X–70-B holding point, which receives all radioactive decontamination solutions from the plant. In addition, the background radiation is essentially the same as it was in 1954. Obviously, there is no widespread radioactivity contamination occurring.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1971	January 1974

2. Shippingport Atomic Power Station[a] January–December 1972

Duquesne Light Company
Shippingport, Pa.

The Shippingport Atomic Power Station is located on the south bank of the Ohio River on a 1.8 km² site. The site is approximately 1.6 km from Midland, Pa., 8 km from East Liverpool, Ohio, about 40 km west of Pittsburgh, and about 18 km below the confluence of the Beaver and Ohio Rivers (figure 2).

Operation of the pressurized water reactor at the Shippingport plant has supplied power to the Duquesne Light Company system, in addition to providing technology which has served as a basis for the development of pressurized water reactors in the nuclear industry. The present nuclear reactor installed at Shippingport is designed to produce 150 000 kilowatts of electrical power, although it is normally operated at or below the electric turbine-generator capacity of 100 000 kilowatts.

Liquid effluents from the plant are collected, processed, sampled, and analyzed to ensure conformance with the applicable water quality standards prior to release to the environment. Liquid effluents containing radioactivity are processed to reduce the amount of radioactivity to the lowest practical level. All releases of radioactivity from the plant site from initial operation to the present time have been carefully controlled to levels well below those specified in Atomic Energy Commission Manual Chapter 0524. Shippingport releases have been less than the limits agreed to with the Commonwealth of Pennsylvania. In addition, releases from the AEC contract portion of the power station have been in compliance with the water quality standards specified by Atomic Energy Commission Manual Chapter 0510 and have been within the guidelines established by the Ohio River Valley Water Sanitation Commission (*1*), and the Commonwealth of Pennsyl-

[a] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, Shippingport Atomic Power Station, January–December 1972."

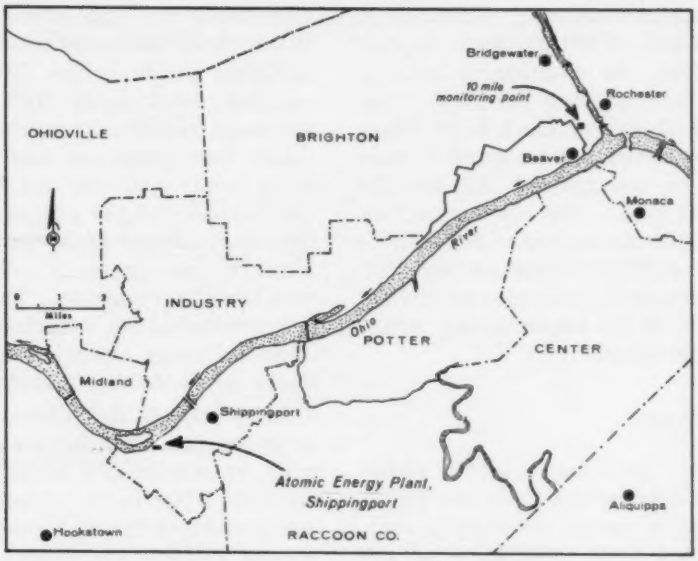

Figure 2. Shippingport Atomic Power Station sampling locations

vania (*2*). The results of environmental monitoring at Shippingport Atomic Power Station during 1972 show that plant operations have had no significant effect on the natural radiation levels in environment outside the station.

Effluent water quality

Water containing radioactivity is generated primarily from draining the reactor coolant system and decontaminating equipment. The plant is equipped with systems to collect and process this water and remove most of the radioactivity before it is released to the Ohio River.

The principal source of radioactivity in water from the reactor coolant system is trace amounts of corrosion and wear products from the inner metal surfaces of the reactor plant. The primary long-lived corrosion product radionuclide is cobalt-60, with a half-life of 5.3 years. This radionuclide has also been shown to be predominant by independent analysis by the Bettis Atomic Power Laboratory. In addition, a number of short-lived radionuclides are produced in the reactor coolant along with relatively long-lived tritium, which has a 12.3 year half-life. Because of the small initial concentrations and rapid decay, the concentrations of the short-lived radionuclides are negligible after holdup of the water in the radioactive liquid processing system, leaving the longer-lived cobalt-60 and tritium.

Fission product concentrations in the reactor coolant have been low relative to the levels of corrosion product radioactivity because the fuel element cladding has not had defects. Very low levels of fission products in reactor coolant are produced by fission of trace amounts of natural uranium impurities in the fuel cladding.

Prior to release from the site, water containing radioactivity is carefully processed through the radioactive liquid processing system to remove most of the radioactivity. This system includes filtration, ion exchange, evaporation, and equipment for monitoring the radioactivity levels in the holdup tanks.

During 1972, a total of 13 mCi of long-lived gross beta-gamma radioactivity, exclusive of tritium, and 670 mCi of tritium were released to the Ohio River. In addition, 1 mCi of fluorine-18 was released from the plant. Fluorine-18 has a half-life of less than 2 hours. These amounts of radioactivity are too small to have had any effect on the natural radioactivity levels in the Ohio River. The average concentration of radioactivity in water released to the Ohio River was 0.22 percent of the AEC standard for total activity, exclusive of tritium, and 0.018 percent of the concentration standard for tritium in water.

Gaseous radioactivity

Normal reactor operation produces radionuclides such as noble gases from the fission of trace impurities of natural uranium in reactor structurals and from irradiation of the reactor coolant water. Since there have been no defects in fuel element cladding, the fission products level in the reactor coolant have been low. Gases are removed from the reactor coolant system by venting to the gas system. The vent gas system contains the gases for sufficient time to permit radioactive decay and sampling of the gases for analyses prior to release to the environment.

A total of 1 mCi of radioactive gases, primarily xenon-133, was released from the vent gas system to the environment during 1972. In addition, an estimated 1 mCi of xenon-133 was released by all other paths from the plant. The total airborne and gaseous radioactivity, xenon-133, released from Shippingport over its operational history since December 1957 has been less than 1 curie. The small amount of gaseous radioactivity released from Shippingport has had no significant effect on the natural radiation levels in the surrounding area.

Environmental monitoring program

Environmental monitoring surveys adjacent to the Shippingport plant have been performed since prior to initial startup in 1957. A continuous environmental monitoring program has been carried out during the 15 years of plant operation to assure the adequacy of procedures and limits for the release of radioactivity. Water from both upstream and downstream sampling points in the Ohio River has been sampled continuously and analyzed weekly, sediment samples from the river have been taken from upstream and downstream sampling points quarterly and film badges around the boundary of the station and from a 16-km distance control point have been evaluated monthly. See figures 2 and 3 for monitoring and sampling locations. The results of these surveys have been reviewed both by the U.S. Atomic Energy Commission and the Commission's Bettis Atomic Power Laboratory.

In addition to the environmental monitoring program conducted by Duquesne Light Company, an independent environmental survey of the Ohio River in the vicinity of Shippingport was performed during November 1970 by Bettis Atomic Power Laboratory. Bettis Laboratory concluded that Shippingport Atomic Power Station operations have had no adverse effect on the Ohio River.

Ohio River water analysis

During 1972, weekly composite samples were analyzed from two continuous automatic samplers in the station circulating water line upstream and downstream of the radioactive waste effluent release point. These samples were analyzed for gross alpha and beta-gamma radioactivity, on both suspended and dissolved solids, and also for potassium-40 content. As depicted in table 4, no significant difference was observed among the average alpha, beta-gamma and potassium-40 radioactivity for the influent and effluent samples for the river samples obtained during 1972.

Ohio River sediment analysis

The Ohio River bottom silt in the vicinity of Shippingport is sampled quarterly, to a depth of approximately 5 cm, upstream and downstream of the plant release point. During the years of plant operation, and even before plant operations began in 1957, measurements of sediment have shown a wide variation in radio-

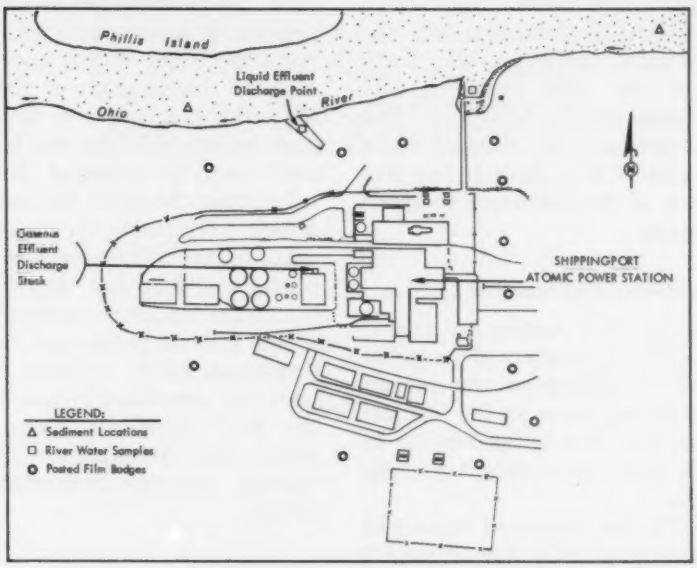

Figure 3. Shippingport liquid and gaseous effluent discharge points

Table 4. Gross radioactivity in the Ohio River, Shippingport Atomic Power Station, January–December 1972

Type of radioactive material	Number of samples per quarter [a]	Position	Average concentration (pCi/liter)			
			Jan–Mar	Apr–June	July–Sept	Oct–Dec
Alpha: [b]						
Total solids	13	Upstream	1.7	1.3	1.8	2.5
		Downstream	1.5	.9	1.3	2.9
Beta: [c]						
Total solids	13	Upstream	10.0	8.4	9.2	13.0
		Downstream	7.2	8.0	12.0	15.3
Potassium-40 [d]	13	Upstream	3.8	4.6	5.9	3.8
		Downstream	3.7	4.6	5.7	4.0

[a] The number of sample sets, both upstream and downstream.
[b] The 90-percent confidence level of average alpha radioactivity determinations is 0.2 pCi/liter.
[c] The 90-percent confidence level for average beta-gamma radioactivity determination is 0.7 pCi/liter.
[d] The 90-percent confidence level for average potassium-40 radioactivity determination is 0.4 pCi/liter.

activity, both upstream and downstream, caused by the radionuclides uranium, thorium, and daughter products of radium which occur naturally throughout the Ohio River basin and are washed into the river. Over the years, 1967 through 1971, the radioactivity in silt samples taken upstream from Shippingport, and thus reflecting natural radioactivity, varied between 2.5 and 17.0 pCi/g, with an average value of 8.2 pCi/g. This wide variation was also exhibited in the downstream silt measurements, which have an average value of 9.0 pCi/g.

In 1972, the river sediment sample activity averaged 2.4 pCi/g upstream and 2.8 pCi/g downstream, which is significantly below previous years. This is due to an improvement in counting capability which has provided a higher sensitivity. Since previous samples were within the minimum detectable activity range of previous methods, this greater sensitivity is re-

flected by activity values below those which were previously detectable. Consistent with the results of previous years, there is no significant difference between the 1972 upstream and downstream sediment sample activities. The small amount of radioactivity released from Shippingport Atomic Power Station has had no significant effect on the radioactivity levels of the river sediment.

Environmental radiation monitoring

Twelve beta-gamma film badges are posted and processed monthly throughout the year at the site perimeter. To determine the normal background levels of radiation in the vicinity of the station, a control film badge location is established 16 km from the station boundary in Bridgewater, Pa.

For the year 1972, the measured exposures on the site perimeter monitoring films were not measurably different from the natural background exposures on the control films. The monitoring results show that the radiation exposure to the general public outside the station is not above that received from natural background radiation.

Estimates of radiation dose to man

Even though the results of environmental monitoring show that the small amounts of radioactivity released from Shippingport have had no significant effect on the surrounding environment, conservative estimates of the radiation dose to man from radioactivity released have been made by analyzing the pathways whereby radioactivity might be transmitted from the environment to man. These analyses considered direct exposure, such as by drinking Ohio River water, and indirect pathways such as consumption of fish. These analyses showed the exposure to man from this radioactivity would be far too low to measure and could only be estimated through conservative calculation. Based on the radioactivity released during 1972 (table 5), the maximum radiation exposure in 1972 to any member of the general public would be less than 0.074 millirem. The maximum radiation exposure to any member of the general public and the exposure to the population within an 80-km radius of Shippingport are significantly less than 1 percent of the AEC standards. Thus, radioactivity released from Shippingport has not caused significant radiation exposure to the general public.

Conclusions

The small amounts of radioactivity released from Shippingport Atomic Power Station were far less than the limits specified by the Atomic Energy Commission and the Commonwealth of Pennsylvania. The results of the environmental monitoring described in this report show that Shippingport operations have had no significant effect on the environment around the plant.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1971	October 1973

Table 5. Annual liquid and gaseous radioactive waste discharges Shippingport Atomic Power Station, 1970–1972

Year	Radioactive liquid wastes released to the Ohio River				Gaseous wastes released to the environment (mCi)
	Total activity (excluding tritium) (mCi)	Percent of AEC standard	Tritium activity (Ci)	Percent of AEC standard	
1970	70	1.20	1.71	0.047	<1
1971	46	.79	.66	.018	* 0
1972	13	.22	.67	.018	1

* No gases were released due to adequate holdup capacity.

REFERENCES

(1) ORSANCO. Pollution Control Standard 1–70 and 2–70, Ohio River Valley Water Sanitation Commission ORSANCO, 414 Walnut Street, Cincinnati, Ohio 45202.

(2) COMMONWEALTH OF PENNSYLVANIA DEPARTMENT OF HEALTH. Sanitary Water Board, Industrial Wastes Permit No. 1832.

Erratum

An error occurred in table 3 (Laboratory gamma analysis of the dissolved component of water samples) page 44 of the report "A Radioactive Isotopic Characterization of the Environment Near Wiscasset Maine: . . ." that appeared in the February 1974 issue of *Radiation Data and Reports*. The second sample under "Young's Creek" should have appeared as the first sample under "Chewonki Neck." The corrected table appears below.

Table 3. Laboratory gamma analysis of the dissolved component of water samples [a]

Location and distance from reactor site	Type	Date collected (1972)	Date counted (1972)	Potassium [b] (g/liter ±2σ)	Cesium-137 (pCi/liter ±2σ)	Radon-222 (pCi/liter ±2σ)
Foxbird Island 0.1 km S	Estuarine	6/13	6/22	0.18±0.06	<2.0	<4.0
Eaton Farm 0.4 km W	Well	6/13	6/22	<.10	<2.0	<4.0
Bailey Farm 0.8 km NE	Well	6/13	6/22	<.10	<2.0	81.0±13.0
		6/13	6/29	<.10	<2.0	<4.0
Young's Creek 1.0 km N	Surface	6/13	6/22	<.10	<2.0	<4.0
Chewonki Neck (camp) 1.9 km SW	Well	6/13	6/22	<.10	<2.0	98.2±19.2
		6/13	6/27	<.10	<2.0	<4.0
Cowseagan Narrows 3.2 km NE	Estuarine	6/13	6/22	.19± .06	<2.0	<4.0
Bluff Head 4.0 km SSW	Estuarine	6/13	6/22	.16± .06	<2.0	<4.0

[a] All samples were counted for 50 minutes in a 3.5 liter Marinelli beaker geometry.
[b] Determined by measuring potassium-40

Reported Nuclear Detonations, September 1974

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission reported a nuclear test in the yield range of 20–200 kilotons was conducted at its Nevada Test Site on September 26, 1974, by the Atomic Energy Commission.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ENVIRONMENTAL MONITORING AND DISPOSAL OF RADIOACTIVE WASTES FROM U.S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES, 1973. *M. E. Miles, G. L. Sjoblom, J. D. Eagles. Radiation Data and Reports, Vol. 15,* September 1974, pp. 625–646.

The environmental effect of disposal of radioactive wastes originating from U.S. Naval nuclear propulsion plants and their support facilities is assessed. The total radioactivity, less tritium discharged to all ports and harbors from the more than 100 Naval nuclear-powered ships and supporting tenders, Naval bases and shipyards was less than 0.002 curie in 1973. The total tritium released to all ports and harbors was less than 1 curie in 1973. This report confirms that procedures used by the Navy to control releases of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public.

KEYWORDS: Discharges, disposal, harbors, monitoring, nuclear-powered ships, radioactivity, U.S. Naval, wastes.

RADIONUCLIDES IN FOODS: MONITORING PROGRAM. *R. E. Simpson, E. J. Baratta,* and *C. F. Jelinek. Radiation Data and Reports, Vol. 15,* October 1974, pp. 647–656.

In January 1973, the Food and Drug Administration notified its food monitoring program to include the radionuclides strontium-90, cesium-137, iodine-131, ruthenium-106, and potassium-40. Samples from eight composite food categories from each of eight separate total diet market baskets plus eight imported commodities from each of 13 separate cities were forwarded to the Winchester Engineering and Analytical Center for analysis. This paper describes the market basket program and gives a breakdown of the types of foods and quantities of each.

The radionuclide levels found in the total diets analyzed in Fiscal Year 1973 are within Range I of the appropriate guidelines, indicating the need for continued surveillance only at the present level.

The levels of radionuclides found in the limited types of edible imported commodities are low enough such that their contribution to the total diet would not be expected to raise the levels of these radionuclides above Range I of the guides.

KEYWORDS: Diet, food, cesium-137, iodine-131, potassium, ruthenium-106, strontium-90, United States.

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